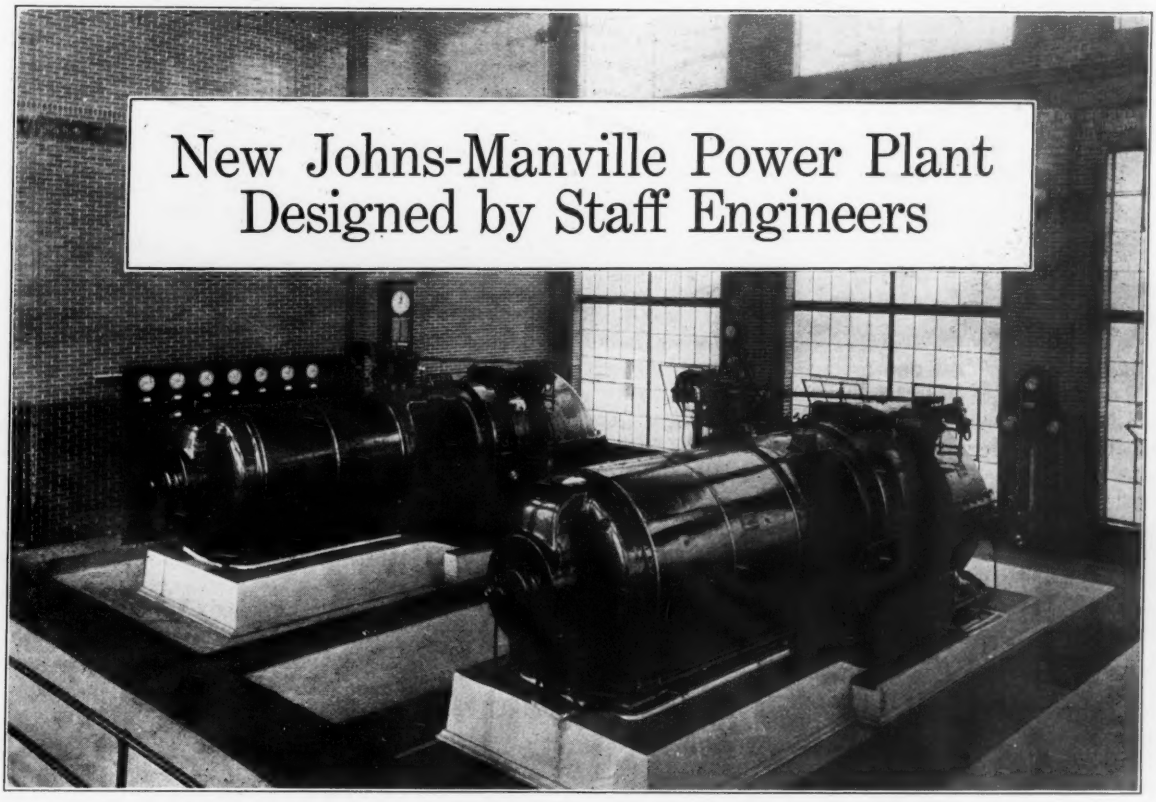
POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

VOL. XXVII CHICAGO, JUNE 15, 1923 No. 12



New Johns-Manville Power Plant Designed by Staff Engineers

NEW MILL BUILT FOR THE MANUFACTURE OF ASBESTOS PRODUCTS IS SUPPLIED BY 4100 HP. OF BOILER CAPACITY AND 5000 KV.A. GENERATOR CAPACITY

HAVING OUTGROWN ITS PLANT in Milwaukee, the Johns-Manville Co., is just completing a new plant on the lake front immediately north of Waukegan, Illinois, for the manufacture of asbestos products. What was formerly an ideal spot for duck hunting in the marsh along the lake is now an equally ideal factory site, convenient to both boat and railway transportation. Some 250 acres of this marsh land has been built up with about 7 ft. of fill and on this man-made ground the plant has been built. Along the north boundary of the property, a canal has been provided for the triple purpose of keeping the land drained, supplying water for manufacturing and power purposes, and for dockage. A spur from the Northwestern and E. J. & E. R. R. which runs along the west boundary provides adequate rail facilities.

One of the most noteworthy features of this plant is that it was designed wholly by the engineering staff of the Johns-Manville Co. under the direction of F. A. Headson, manager of the Milwaukee factories, through whose courtesy it has been possible to present this description.

As indicated on the aerial view of the factory, Fig. 1, the power house is located approximately at the north and south geographic center of the plant; it is also located approximately at the load center of the plant as regards both steam and electrical demands. Ultimately, there will be about 12,000 hp. installed motor capacity, which will be supplied by three generating units totaling 10,000 kw. At the present time, the installed motor capacity is only about half of the ultimate, for which current is supplied by two 2500-kv.a. generating units.

With the exception of the lighting and two synchronous motor installations, the load is composed entirely of induction motors of either the slip ring or squirrel cage type. Due to the fact that these motors are well fitted to the loads which they carry and that both the synchronous motors are over excited, the power factor of the system as a whole is brought up to about 80 per cent.

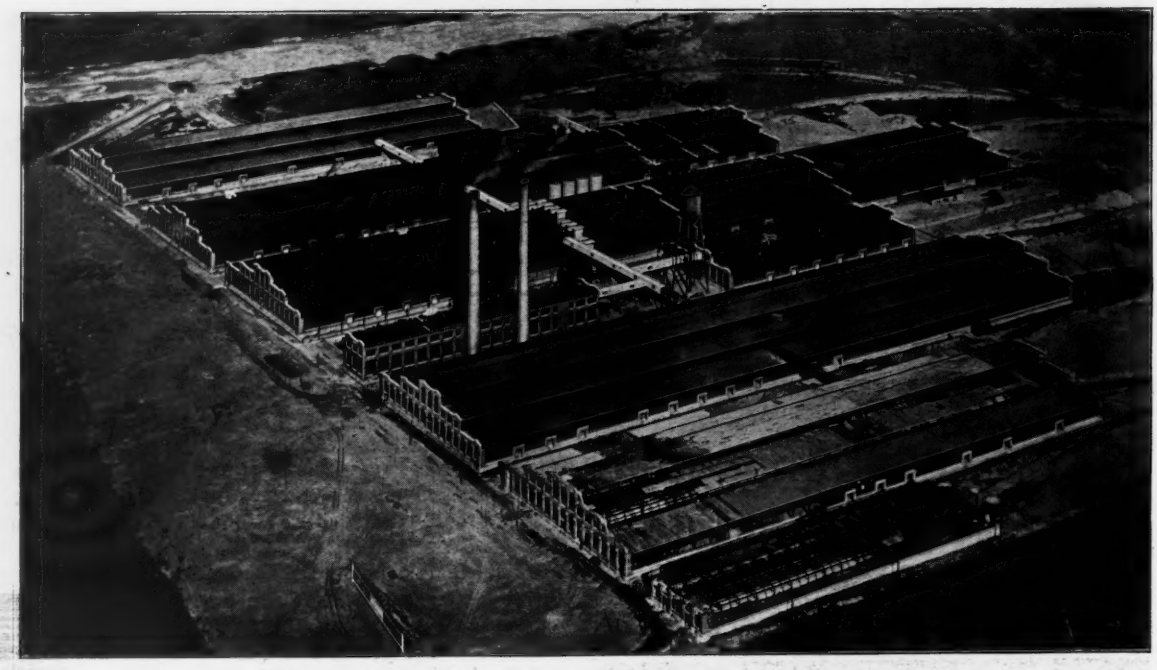


FIG. 1. AERIAL VIEW OF JOHNS-MANVILLE PLANT AT WAUKEGAN, ILL.

One of the two synchronous motor installations is used for driving d.c. generators which supply current for two paper machines. The other is located in the generator room and is used for driving one of the exciters.

Most of the electrical conduit, the high and low pressure steam lines and the condensate return line is carried from the power plant to the various departments and buildings of the factory in an overhead runway which is shown in Figs. 3 and 11-B. The reason for carrying these lines overhead rather than underground

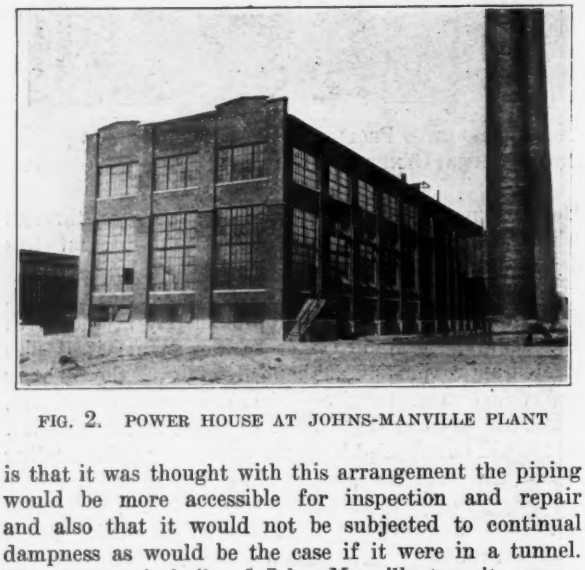


FIG. 2. POWER HOUSE AT JOHNS-MANVILLE PLANT

is that it was thought with this arrangement the piping would be more accessible for inspection and repair and also that it would not be subjected to continual dampness as would be the case if it were in a tunnel. The runway is built of Johns-Manville transite corrugated asbestos wood and at frequent intervals windows are provided to furnish ample illumination on the inside.

As illustrated in Fig. 2, the power plant is housed in a building of its own apart from the manufacturing buildings. This building is some 320 ft. long by 52 ft. wide by about 35 ft. high, and in keeping with the general architecture of the rest of the plant, a great proportion of exposed wall surface is occupied by windows. The turbine room is located at the west end of this building, occupying a space about 52 by 84 ft. The floor level is about 4 ft. above that of the boiler room and about 8 ft. above the ground. The walls are finished with a mottled green tile which presents a very pleasing effect. Arrangement of the various units in the turbine room may be noted by reference to the plan drawing shown in Fig. 9. The switchboard is located along the west wall and the two generating units are placed side by side near the east end of the room. Between the turbines and the generator are the two exciter units, and adjacent to them is a space left for a future generating unit.

Turbine Room

As shown in the head piece, the two units which are installed are identical in every respect. Each is a General Electric 2500-kv.a. turbo-generator of the rigid frame, three-point suspension type. As generated, the current is three-phase, 60-cycle, 480-v. No transformers are employed and the current is used at this potential throughout the plant, all motors being rated for 440 v. At rated load, each generator output is 3007 amp. per phase, which, at the prevailing power factor of 80 per cent, give a 2000-kw. rating. The drive is a Curtis four-stage automatic extraction turbine shown in section in Fig. 6, which takes steam at 190 lb. gage, and exhausts under a vacuum of 28½ in. of mercury as referred to a 30-in. barometer.

Demand for exhaust steam for manufacturing processes is supplied by extraction from the second stage of the turbine at a pressure of about 5 lb. gage. The demand for steam varies, of course, as does also the demand for electrical energy which affects directly the steam supply. These variations would effect a wide fluctuation in the extraction pressure, to prevent which, an automatic ex-

traction valve is used which controls the amount of steam admitted to the succeeding pressure stages in the turbine in such a way as to maintain a constant pressure in the extraction header. A careful check is kept on the operation of the turbine by means of high pressure, extraction pressure and vacuum gages, and a speed indicator, which are mounted on an individual panel adjacent to the unit.

Excitation current is supplied for both generators by either one of two exciter units. One is a compound wound 50-kw., 125-v., 400-amp., 3600-r.p.m. General Electric generator shown in Fig. 7, direct connected to a single stage Curtis turbine operating on 190 lb.

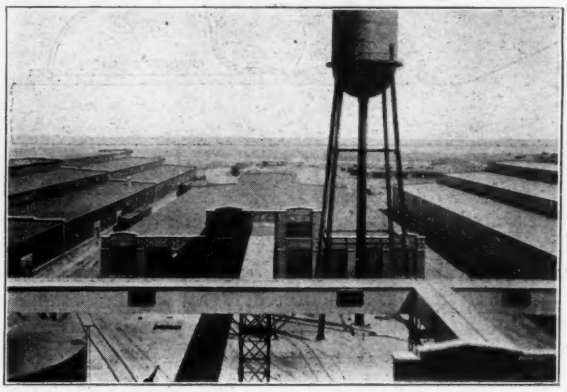


FIG. 3. OVERHEAD RUNWAY CARRYING PIPE LINES AND CONDUIT TO THE VARIOUS DEPARTMENTS OF THE PLANT

steam pressure. The second is a General Electric synchronous motor driven unit shown in Fig. 8 which runs at 900 r.p.m. The generator output is the same as that of the steam driven unit, i.e., 400 amp. at 125 v. The synchronous motor is a 75 hp. three-phase, 60-cycle unit which takes 66 amp. at 440 v. from the station bus. Excitation for this motor is supplied by a direct connected exciter which delivers 64 amp. at 125 v. In addition to these two units there is also provided a 25-kw. motor generator set which may be used in case of emergency. The motor may be supplied from either the station or public service bus. At full length it takes 48 amp. at 440 v. and develops 40 hp. The generator output corresponding to this load is 200 amp. at 125 v. Ordinarily the synchronous motor driven exciter is used, the turbine driven unit being employed only for starting up, or in case the steam demands in the plant exceed the maximum possible amount that may be extracted from the turbines at the load under which they are operated. In this case, the turbine driven exciter may be used and the exhaust bled into the extraction header.

Each department of the plant, including the packing building, the cement building, the mastic and melting departments, the machine room of the roofing building, the shingle mill and pipe covering building, machine room and the beater room of the paper mill is represented by an individual panel on the switch board, shown in Fig. 4. The remaining panels are devoted to a public service bus tie, and the power house units. The board is made of Johns-Manville ebony asbestos board composition and contains 22 panels. Integrating meters are installed on all outgoing lines and an accurate check is

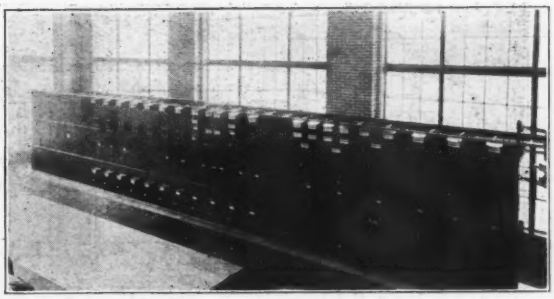


FIG. 4. SWITCH BOARD

kept of the power consumption of each department day by day. In addition, there is an ammeter on each line. The power house panels are equipped with indicating, recording and integrating watt meters, volt meters, a. c. and d. c. ammeters, frequency indicators, temperature indicators for the generator and synchronizing indicators.

Immediately under the switchboard is the automatic switching equipment shown in Fig. 5, which is actuated by remote control from the board. Bus bars are used throughout for generator leads.

Condensing equipment for the turbines is located directly beneath the units which they serve, in the turbine room basement. These units shown in Fig. 11-F are the Worthington low level multijet condensers, which

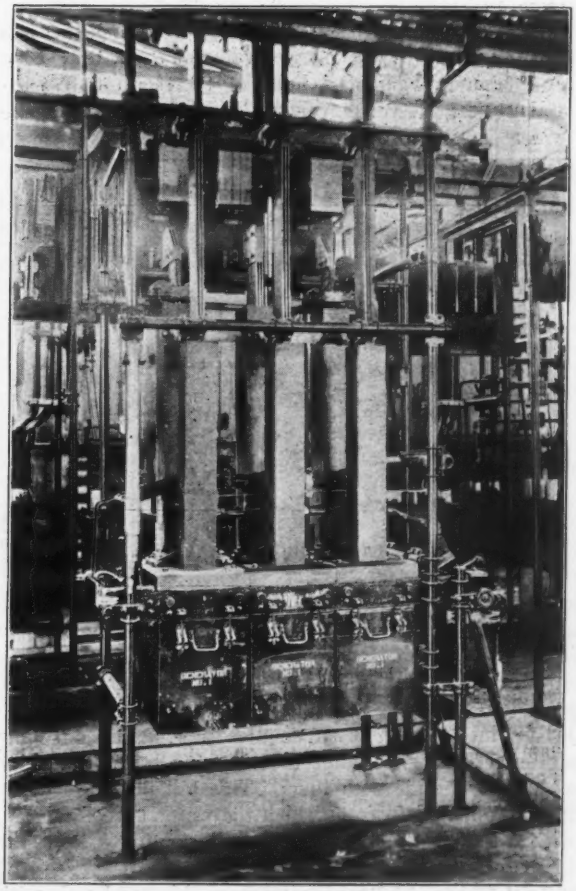


FIG. 5. SWITCH GEAR AND BUS STRUCTURE

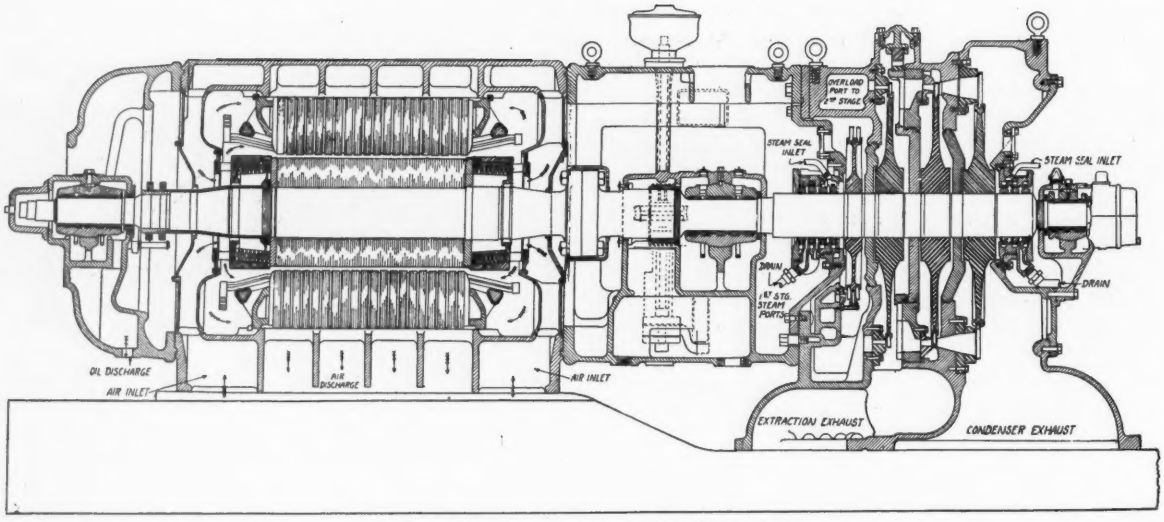


FIG. 6. SECTION OF TURBINE AND GENERATOR

with circulating water at a maximum temperature of 70 deg. maintain a vacuum of 28½ in. The condenser is connected to the turbine through a 42-in. diameter by 24-in. copper expansion joint and a 42-in. Chapman valve having a 16-in. back outlet open to the atmospheric relief valve on the roof. A Worthington double runner tail pump mounted directly beneath the condenser chamber is driven through a Pool reduction gear by a 100-hp. Terry turbine, shown in Fig. 13. Connected to this same shaft through a flexible coupling there is a supply pump which delivers water at the rate of 1000 gal. per min. against a head of 90 ft. to a Worthington hydraulic vacuum pump, which at 2 in. abs. pressure is capable of removing 8 lb. of air per hr. from the condenser. This pump is equipped with a 10-in. water inlet and a 10-in. air suction line. Water emerges through a small annular orifice and impinges on a rotor provided with inclined veins which serve to break the jet up into a number of smaller jets having a rotary motion. These jets enter the tail pipe at high velocity and carry the air with them. This tail pipe discharges into an open sump from which the water is recirculated, with a sufficient amount of cold make-up to keep the temperature within the desirable limits, back to the supply pump. The arrangement of this condenser with its piping is shown diagrammatically in Fig. 12.

Located directly beneath the generator is a Spray Engineering Co. air washer which cools the generator circulating air. The system is of the closed type so that little if any dust is encountered. This washer is capable of handling 9000 cu. ft. per minute with a water consumption of 78 g.p.m. at 25 lb. maximum pressure. Ordinarily the energy lost from the turbine amounts to 120 kw., which causes a 12.5 deg. rise in the air circulated. With 25 lb. pressure at the nozzles, the contact between the water and air is so intimate that there is a maximum temperature difference between the two of only 4 deg. If for any reason the water supply should fail, the temperature of the air would immediately rise and would melt a fuse link which would allow two doors in the intake duct to the cooler to open. This arrangement permits the heated air from the generator to be discharged into the turbine room basement and relatively cool air to be drawn in.

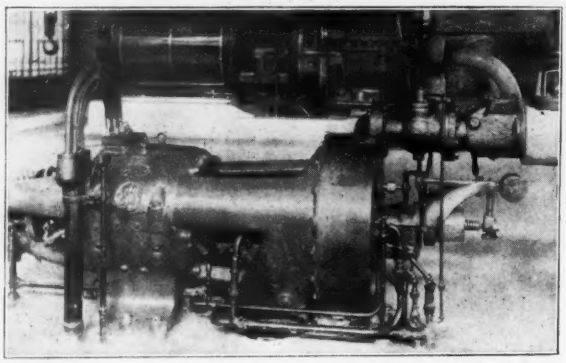


FIG. 7. TURBINE DRIVEN EXCITER

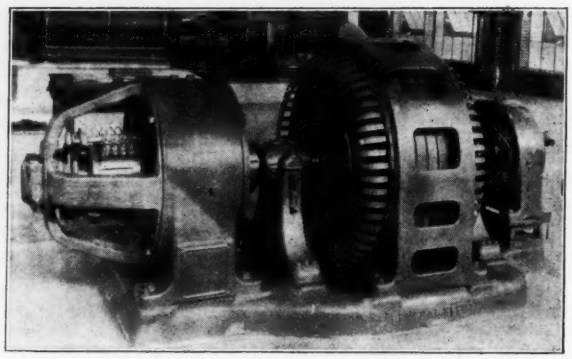


FIG. 8. SYNCHRONOUS MOTOR DRIVEN EXCITER

As shown in Fig. 14, the boiler feed pumps are also located in the turbine room basement. These pumps are installed in duplicate for safety. Each is a three-stage Worthington centrifugal pump direct connected to a Terry turbine developing at full load 150 hp. The rated capacity of the pump is 500 g.p.m. against a 235-lb. head. Feed water at a temperature of about 205 deg. flows to the pump section under a head of about 18 or

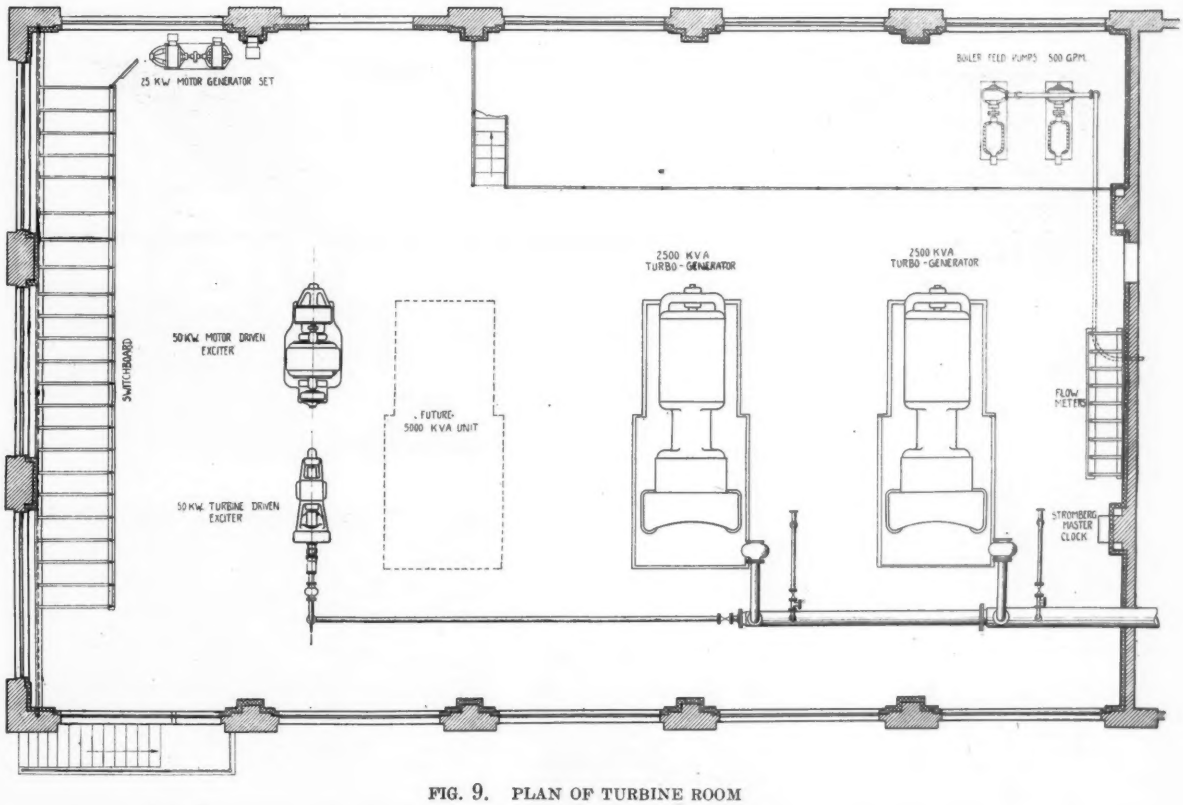


FIG. 9. PLAN OF TURBINE ROOM

20 ft. from the feed water heater which is located in the boiler room. Discharge to the boilers is by means of a loop system, one side of which runs along the top of the boilers and the other through the boiler room basement.

Boiler Room

For the present requirements of the plant steam is supplied by eight Babcock and Wilcox 512 hp. boilers. These units are set in pairs and arranged in a single line

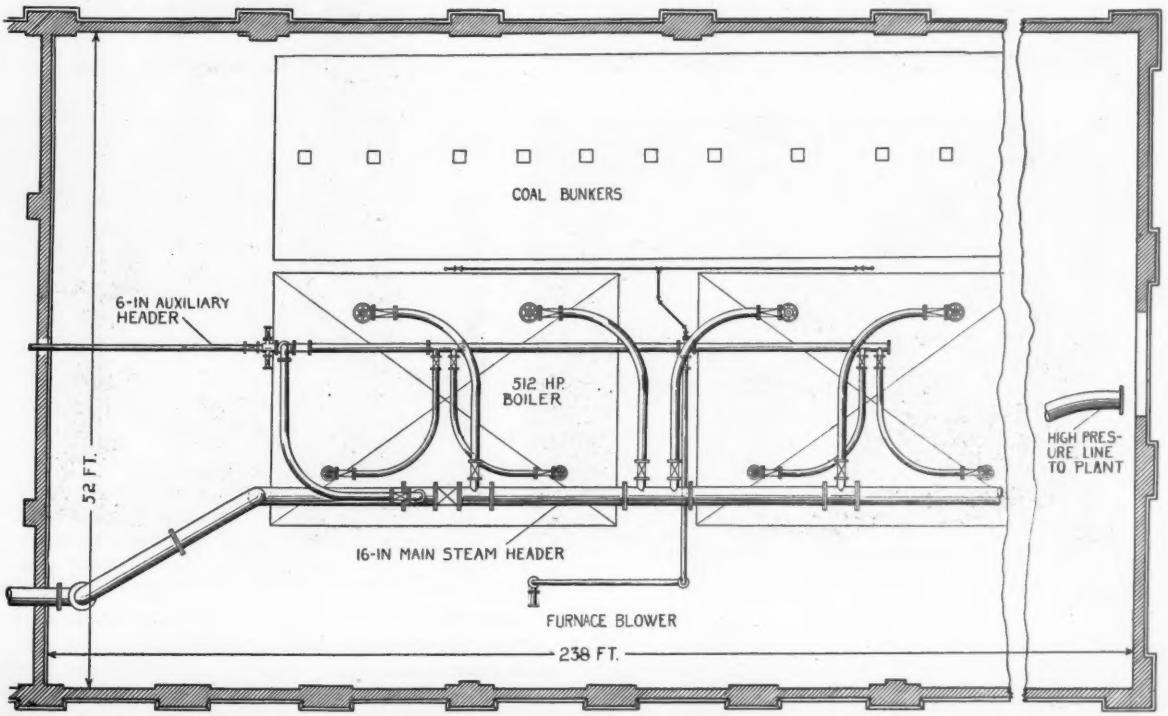


FIG. 10. PLAN OF BOILER ROOM

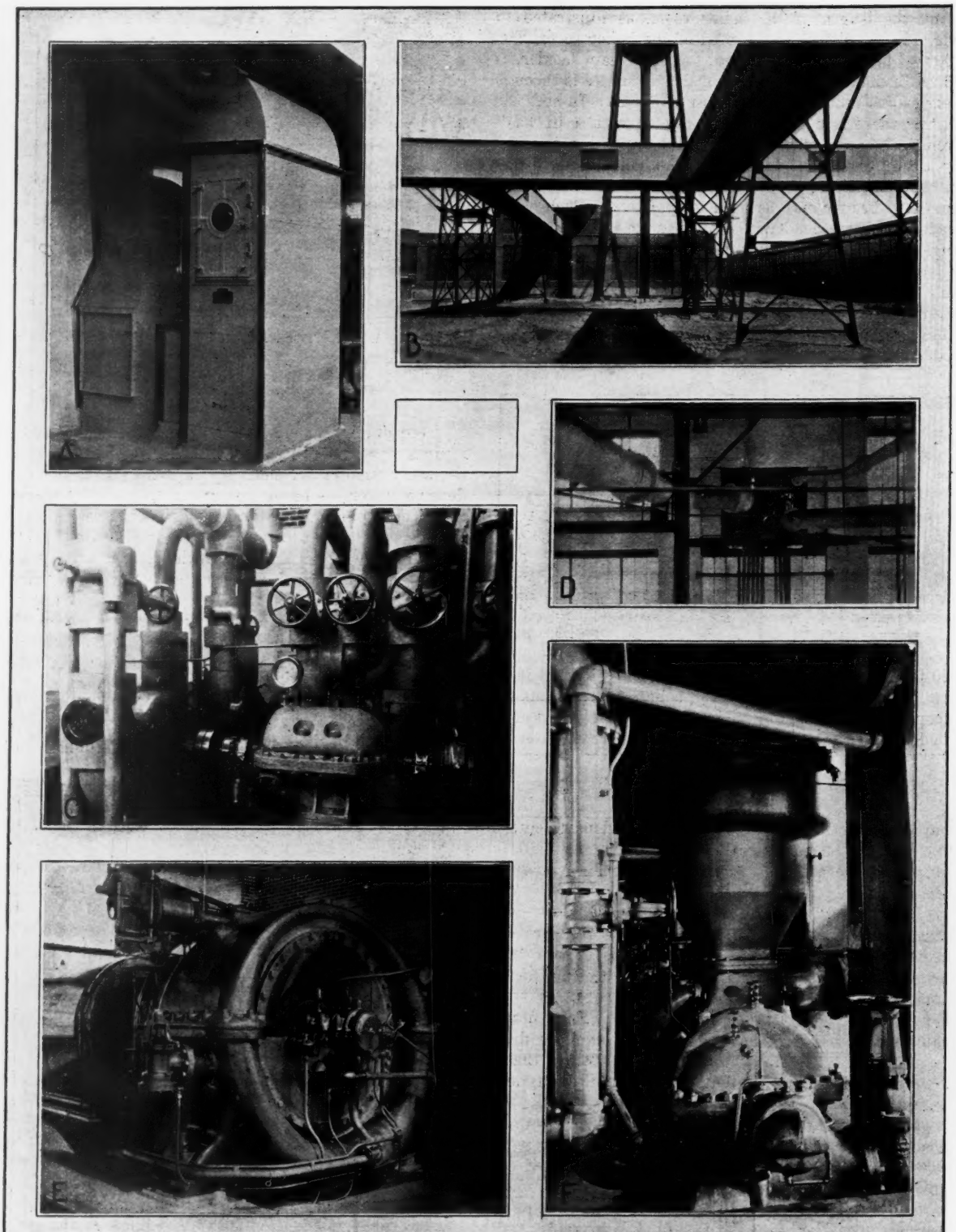


FIG. 11. A, GENERATOR AIR WASHER; B, PIPING AND CONDUIT RUNWAY; C, TURBINE DRIVEN BOILER FEED PUMPS; D, PIPING ENTERING RUNWAY AT EAST END OF BOILER ROOM; E, 2000 KW. TURBINE, AND F, WORTHINGTON CONDENSER

along the length of the boiler room, as illustrated in Fig. 16. As shown in the plan of the boiler room, Fig. 10, two headers are provided, one, the main header, is 16 in. in diameter and is supplied by 6 in. leads through long radius bends from each pair of drums. In addition to this there is 6 in. auxiliary header with 4 in. leads from each boiler. These two headers are tied in together by a 6 in. line at the west end of the boiler room so that in case anything happens to the main header, the auxiliary header may be used temporarily. Each boiler lead to the main header is equipped with three valves, an angle globe valve, an automatic non-return and a gate valve, the globe valve being located adjacent to the boiler and the non-return between it and the gate. The main header extends into the turbine room where two 8-in. lines are taken off for supplying the main turbines. It also extends in the other direction into the overhead run-

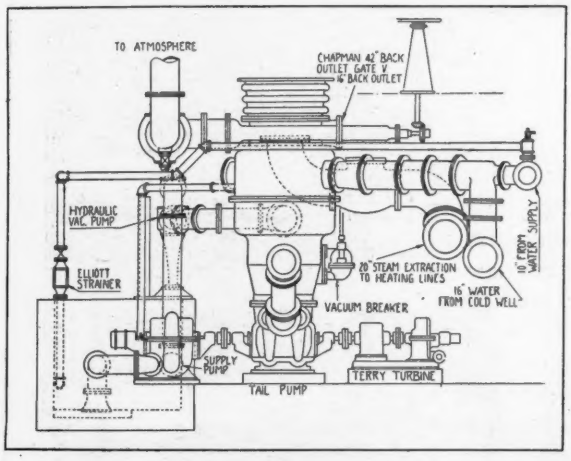


FIG. 12. CONDENSER EQUIPMENT

way where it is carried to the various departments of the plant. The auxiliary header is ordinarily used for supplying the auxiliary equipment in the turbine and boiler room.

Each boiler contains 252 4-in. tubes 18 ft. long, arranged 18 wide and 14 high. These tubes are connected by means of two sets of headers to two 42-in. drums 20 ft. 5½ in. long. The total heating surface amounts to 5117 sq. ft., which at 10 sq. ft. per boiler horsepower, gives a rating as specified. Each unit is equipped with four 3-in. safety valves, two per drum, set to blow at 2 lb. above the working pressure; that is, 202 lb. All boilers are equipped with Stets type B regulators.

Each main steam head lead from the boilers to the header is equipped with a Republic steam flow meter, the indicating instruments for which are mounted on a board, shown in Fig. 17 in the turbine room. These instruments include an indicator, a recorder and an integrator. The auxiliary leads are also provided with meters which register on an integrating device mounted on the meter board. In addition to this each department of the plant is provided with an integrating meter. Careful record is kept on these meter readings and in this way a check is kept on the performance of each boiler and also on the steam consumption of each department.

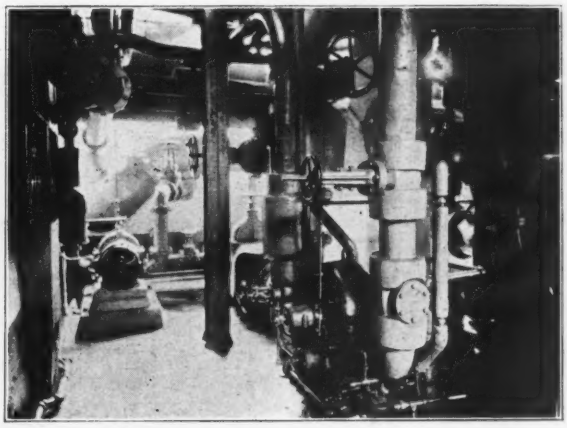


FIG. 13. 100 HP. TURBINE DRIVING CONDENSER TAIL PUMP AND HURLING WATER SUPPLY PUMP

Feed water is made up largely by the condensate returns from the various manufacturing processes, the necessary amount of make-up is taken from the condensing water discharge line and is pumped by a small centrifugal pump from the turbine room basement to a surge tank located directly under the ceiling in the boiler room where it mixes with the returns. The water level in this surge tank is controlled by two float valves, one of which controls the Terry turbine driving the pump furnishing the make-up. If, for any reason, this pump is inoperative the second control opens a valve in the cold water service lines and the make-up is taken from this source. This tank is 6 ft. in diameter by 10 ft. high and has a capacity of 2000 gal. From it the feed water flows by gravity through an open pipe, 5000 hp. Cochrane feed water heater located immediately

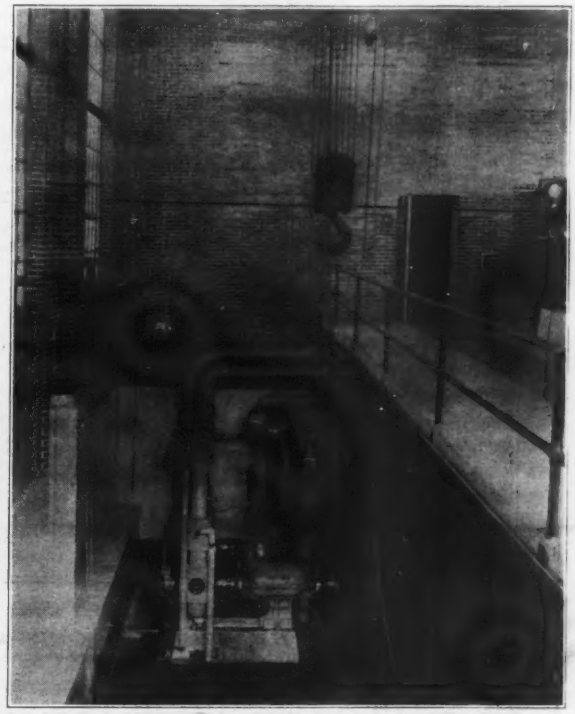
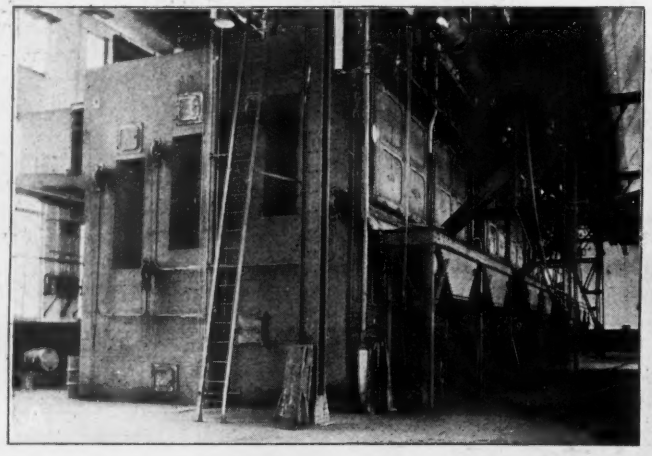
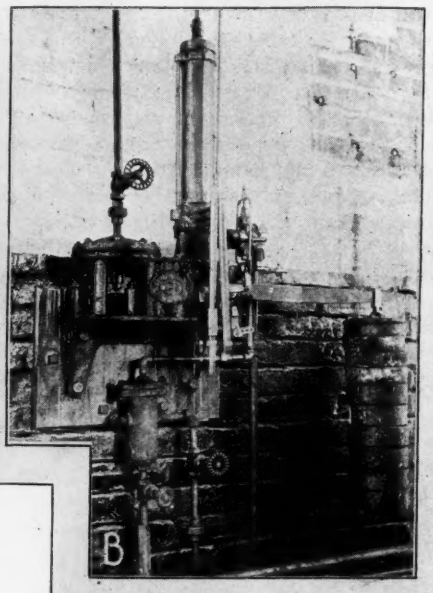


FIG. 14. DUPLICATE BOILER FEED PUMPS





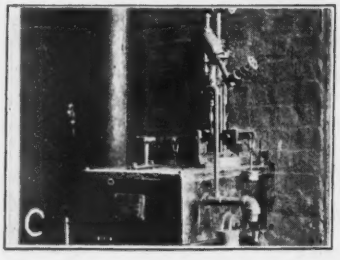
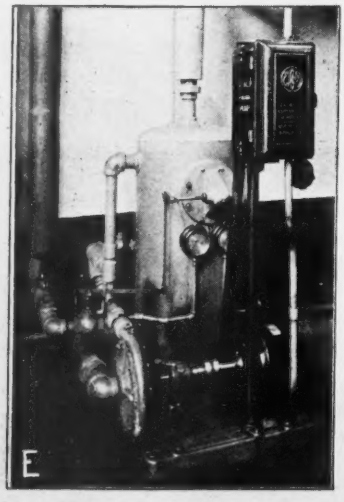
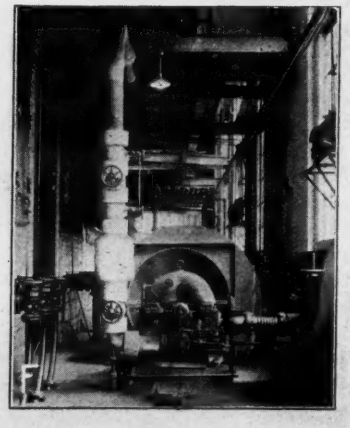
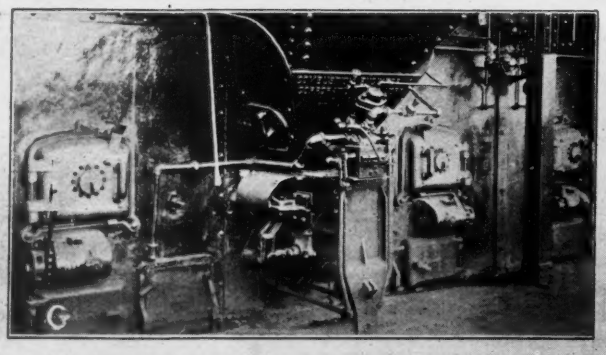


FIG. 15. GLIMPSES OF THE BOILER ROOM. A, BATTERY OF BABCOCK & WILCOX BOILERS FROM THE EAST END OF THE BOILER ROOM; B, RUGGLES-KLINGEMANN BLOWER AND STOKER CONTROL; C, FESSENDEN-ELLIS GASOMETER TYPE DAMPER REGULATOR; D, REPUBLIC STEAM FLOW METER BODIES; E, RETURN PUMP FOR HIGH PRESSURE DRIPS; F, TURBINE DRIVEN FORCED DRAFT FAN; G, TYPE E SINGLE RETORT STOKER; H, MAIN STEAM HEADER ALONG TOPS OF BOILERS







below. Here under a back pressure of approximately 5 lb. it is heated to 205 deg. by the exhaust from the various auxiliary units in the turbine and engine rooms. From the heater the feed flows to the suction of the boiler feed pumps in the turbine room and is pumped through either one of two 4-in. feed water lines to the boilers.

Insulation for the boilers is 80 per cent magnesia covering. All high pressure steam lines are covered with broken joint sponge felted asbestos. All low-pressure, condensate return and feed water lines are covered with asbestos cell insulation.

Condensate from the high and low pressure lines inside the boiler room proper is trapped to a Young condensate return system shown in Fig. 15-E, which returns the condensate direct to the surge tank. This apparatus

FIG. 16. BOILER ROOM FIRING AISLE

is equipped with a small 2-hp. induction motor driving a 25-g.p.m. centrifugal pump at 1800 r.p.m.

Each boiler is equipped with a Combustion Engineering Co. type E single retort side dump stoker, shown in Fig. 15-G, having an area of 86.7 sq. ft. which is capable of operating at 200 per cent rating for 4 hr. and 150 per cent rating continuously.

Air for combustion for the eight furnaces is supplied by two American Blower Co. Sirocco forced draft fans, one of which is shown in Fig. 15-F. At rating each delivers about 60,000 cu. ft. of air per minute against a static pressure of 5½ in. of water. For ordinary operating conditions, each fan is designed to furnish air for six furnaces; but the ducts are so interconnected that either one of the present fans may be used to supply any boilers in operation. These fans operate at about 1000 r.p.m. and are driven through Poole reduction gears by 150-hp. Terry turbines operating at a normal speed of 3600 r.p.m.

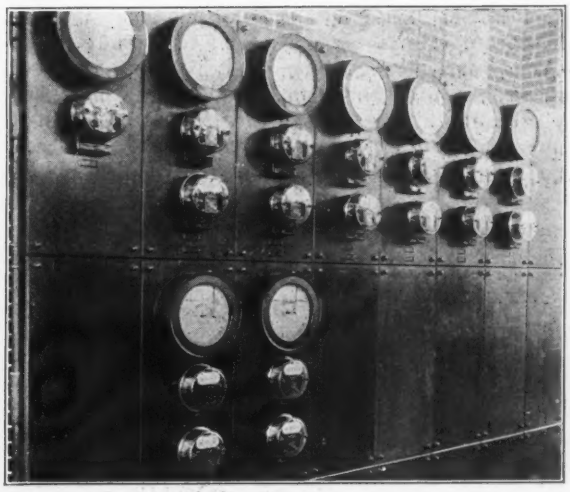


FIG. 17. STEAM FLOW METER BOARD IN TURBINE ROOM

Both fans and stokers are controlled by Ruggles & Klingemann regulators, Fig. 15-B, from the steam pressure in the main header. The quantity of air furnished by the fans is proportional to the stoker speed and both fluctuate with any variation in steam pressure. Each furnace is equipped with a Fessenden-Ellis gasometer type damper regulator shown in Fig. 15-C, which controls the position of the damper in accordance with the draft in the furnaces. Each regulator operates a damper in the breeching connection from each setting and is set to maintain a draft over the fire of 0.2 of water. The breeching is lined throughout with Vitrobestos. Draft is supplied by two Kellogg brick stacks 202 ft. high from the boiler room floor and 12 ft. diameter at the top.

Coal and Ash Handling

Ash is deposited in a hopper beneath the furnace, from which it is withdrawn periodically and raked into a Conveyors Corp. steam jet ash conveyor, as shown in Fig. 18. Two of these conveyors are installed; each takes care of four furnaces. Each consists of a 9-in. line, which runs along on the basement floor just below the line of ash doors, and then out to the storage pits. Each conveyor is equipped with one 9/16-in. jet which is sufficient to convey the ash to the temporary hopper immediately outside the boiler room. To prevent the escape of ash pit fumes and dust into the boiler room basement, while the ashes are being removed, a duct is

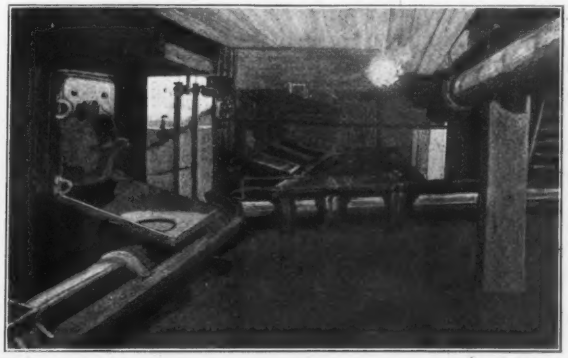


FIG. 18. STEAM JET ASH CONVEYOR IN BOILER ROOM BASEMENT

provided which opens into each ash pit. This duct discharges into the suction end of the conveyor system so that any obnoxious gases or dust which may be present are disposed of in this manner. The conveyor is made up of lengths of half sections of cast iron pipe which are bolted, independently of each other, to two "T" beams which carry the pipe. With this construction any sec-

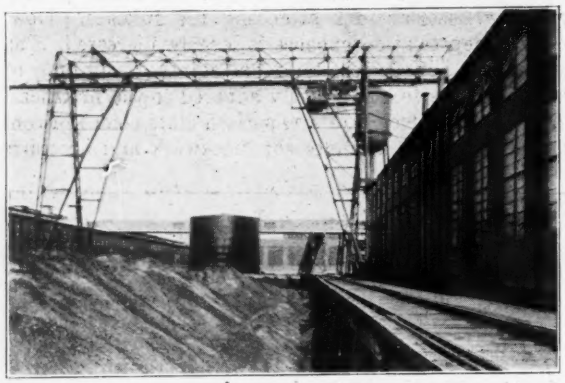


FIG. 19. GANTRY CRANE FOR HANDLING COAL AND ASH

tion that becomes worn may be replaced without disturbing the rest of the line. This system is capable of handling 15 T. of ash per hour.

The coal used is Illinois Screenings which is brought in by rail to a point alongside the power house where it is taken by a clam shell bucket operated from a Lakeside Bridge Co. gantry crane shown in Fig. 19 and dumped into a concrete storage pit having a capacity

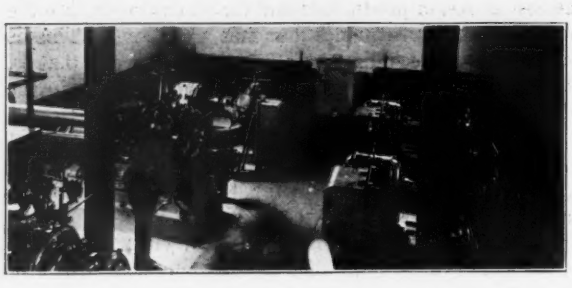


FIG. 20. CONDENSER, SERVICE, AND FIRE PUMPS

of 10,000 T. This pit is fitted with service piping so that in case of fire in the coal pile it may be flooded. A field storage pump is provided in the turbine room basement for draining the pit after it has once been filled. From this storage the coal is handled again by the gantry crane and dumped through hatches in the boiler room roof into an 800 T. concrete lined hyperbolic storage hopper. From the bunker the coal is dropped through suitable gates in the bottom into either one of two 1000-lb. weigh larries from which it is deposited in the 3-T. stoker hoppers on the boiler fronts. The gantry crane is also used to pick up the ash from the ash storage hopper and deposit it in railway cars or trucks.

All service water for the plant and circulating water for the condensers is taken from the canal along the north boundary of the company's property. The pump house on this canal houses five motor driven centrifugal pumps shown in Fig. 20. There are two Worthington fire pumps which have a capacity of 1000 gal. per min. each, against a pressure of 100 lb. This is a one-stage unit having a 13¼-in. impellor, operating at 1750 r.p.m. It is driven by a 100-hp. slip ring variable speed, 440-v., 112-amp. Westinghouse induction motor. The condenser supply pump is a Worthington unit which discharges into a sump outside the turbine room basement. It has a capacity of 2000 gal. against a head of 30 ft. and it is driven by a Westinghouse 20-hp., 69-r.p.m. motor. The two remaining units are Worthington service pumps having a capacity of 2500 gal. each against a 170-ft. head. These pumps are driven by 150-hp. Westinghouse induction motors operating at 1750 r.p.m. They discharge into a 150,000-gal., service tank, shown in Fig. 3, built by the Chicago Bridge Co. There are two outlets from this tank; one is for industrial use which extends up into the tank for a distance of ⅔ the depth and the other is for fire purposes and opens into the bottom of the tank.

Design of Furnace for Burning Powdered Coal

FURNACES IN which powdered coal is to burn must be large enough, and be correctly shaped, so that the coal may burn completely without impinging on the brickwork, and must be provided with facilities for removing the ash, states the Department of the Interior in Bulletin 217, just published by the Bureau of Mines. If the furnace is correctly designed, about 3 B.t.u. per sec. may be liberated per cubic foot of combustion space. This rate of combustion is sometimes exceeded, but if it is much exceeded the coal will not be burned completely.

In many furnaces, the temperature is so high that the ash fuses, and on settling in the furnace collects in a continuous mass. It has become expedient in some furnaces to cook the ash before settling and so prevent it collecting in a continuous mass, though generally this is not done, and the ash collects either on the hearth, whence it is removed when the furnace shuts down, or it is removed as a liquid slag. The ash that does not settle in the furnace goes off with the gases, and care must be taken to see that it may not be deposited in the flues and so impede the draft.

When a furnace previously heated by coal burned on a grate, gas, or oil is to be transformed into a powdered-coal fired furnace, the furnace may or may not have to be modified in design to suit powdered coal. Except for boiler furnaces, very radical alteration of design is unusual. At most, the change consists usually in enlarging the furnace; but no furnace should be fired with powdered coal without the advice of experienced engineers, who will either approve the application of powdered coal to the furnace as it exists or carefully re-design it so that it may be economically operated with powdered coal, using the best means of disposing of the ash.

TO MAKE A barrel, or 376 lb. of cement under ordinary conditions, 200 lb. of coal, or equivalent fuel, must be burned—about three-fifths of it in the kiln. A kiln with a daily capacity of 1000 bbl. of clinker (unground cement) will consume approximately 60 T. of powdered coal every 24 hr.—a ton every 24 min.

Drying of Moist Fuels Outside of the Furnace

When Using Fuels with High Moisture Content, Atmospheric Drying Will Be Found Economical. By Zuce Kogan

DRYING MOIST fuels outside the furnace is the oldest known practice applied to the effective utilization of fuels. It began by the use of the sun's heat and was followed by the use of special drying ovens, drying mechanisms, etc., all of which were abandoned to a more or less extent since the possibilities of drying within the furnace were realized. This is largely due to the great initial cost of these drying arrangements and high cost of operation. Atmospheric drying, for example, requires large areas which, to keep out rain, must be covered with roofs. This, of course, adds greatly to the initial cost, and the large amount of labor required with this system makes for high maintenance expense. It is quite the same with other drying arrangements, such as ovens or mechanical devices, which are necessarily large to contain the great quantities of fuel while their maintenance and heating elements, as fuel, hot air, etc., are expensive.

That all this is true is well understood, but doesn't it cost us anything to dry the fuel within the furnace? And does not the expense of drying within the furnace exceed that of the drying outside the furnace? We have not heard much about such considerations by moist fuel consumers, and it seems that such a comparison has never been made. To shed some light on this question, let us first find the effect of drying inside the furnace on the combustion, and cost of steam generation. We can then discuss the value of outside drying, and if the latter is more economical, take up its possibilities and its features of economy.

Effect of Drying on Combustion and Cost of Steam Production

When moist fuel is dried within the furnace the effect produced by the evaporation of the water in the fuel is generally that of lowering the combustion efficiency and increasing the cost of steam production. The water contained in fuels of high moisture content is rarely of advantage in the combustion of fuel, and even if it is, its effect is so small that it may be considered negligible. The reason is of course that water extinguishes fire, or hinders combustion, technically known as retarding ignition and combustion, but if water could assist combustion in any way it could do it only when separated into its elements, oxygen and hydrogen; but to effect this separation an amount of heat is absorbed from the furnace, such that the net gain possible to obtain from the combustion of these elements becomes exceedingly small.

Considering, on the other hand, the disadvantages of water in the combustion chamber, we know that whether much or little of the water is disintegrated or whether these elements will be of any use or not, the combining of the oxygen and hydrogen to form water will produce excessive temperatures, which will result in the production of great quantities of clinker. With clinker, much of the valuable fuel is lost, and usually the more the water content the greater is the quantity of clinker formed. Due to this clinker, there results a great decrease in fuel efficiency while drying the moist fuel within the furnace.

Not only is the efficiency decreased but the cost of boiler maintenance is increased excessively. The formation of these large quantities of clinker increases greatly the labor necessary for attending the furnace. Now, even the depreciation expense is largely increased. The chipping of clinker results in damaging or chipping of brickwork, due to being firmly adhered to the firebricks. Also, the water rising in a vaporized state comes in contact with the hot incandescent brickwork and abstracts

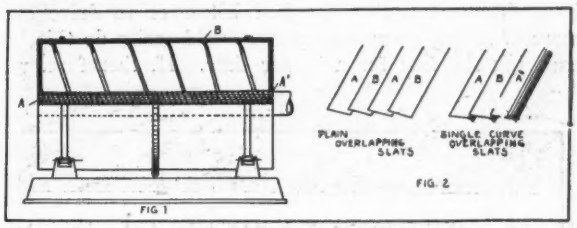


FIG. 1. LONGITUDINAL SECTION THROUGH DRIER IN WHICH GASES ARE MIXED WITH THE FUEL

FIG. 2. DETAILS OF METALLIC SLATS OF PLATFORM TYPE CONVEYOR

very quickly its heat by becoming superheated steam, and this results in cracking of the furnace brickwork. Furthermore we have to consider that this water-vapor is deposited at the cold parts of the economizers, thus augmenting corrosion. All these things affect greatly the cost of steam production and direct drying within the furnace as a consequence becomes expensive. This is only as far as secondary effects are considered; that is, other than taking into account the heat absorbed in the process of drying the fuel.

The Value of Drying Outside the Furnace

With the problem of drying highly moist fuels, we have usually to consider two things:

1st. The economy gained by the drying process.

2nd. The degree of effectiveness possible with the drying.

Drying apparatus, it is well known, is expensive and if a given drying apparatus fails to reduce the moisture in the fuel to a sufficiently low degree, it may not be an economical process. In cases where the drying equipment is comparatively cheap, it is evident that certain effectiveness in drying may be ignored, particularly where the cost of operation is low, as for example, the drying conveyors referred to later in this article. In the latter case we obtained the drying at such a low cost and with such a low initial cost for equipment that the slightest reduction of moisture content is of value. With more elaborate drying equipment, however, the effectiveness of drying is of considerable importance.

With outside furnace drying the economy will depend on the efficiency of the apparatus and the heating medium used, i.e., fuel, hot-air, flue gases, exhaust steam, etc. Referring, however, to atmospheric drying, which is considered as one of the most expensive processes, due to the large amount of space required and because of its high operating cost, we have discovered recently that in

spite of these facts this type of drying is the most economical drying arrangement for peat fuel. That is to say, many authorities on peat fuel claim that unless the fuel is dried to 40 or 30 per cent by the atmosphere, the fuel is of no commercial value as a direct heating fuel. We may assume then, that atmospheric drying, in spite of its high cost features, is usually the most economical process with fuels of very high moisture content. The reason for this is simple, since by increasing the drying space, it permits us to expose the fuel for the longest time without any additional cost of operation. Suppose for instance that we have available a given space for exposing the fuel to the atmosphere, then with a given quantity of fuel to dry per day, the time to leave the fuel exposed becomes limited. Should we now be desirous of drying the fuel better or to drive out more of its moisture content, we could easily do this by exposing the fuel for a longer time. If, therefore, we increase the space, we can increase the time for drying, and we can obtain a better drying without an additional labor expense. This would mean more economical drying, and by following this principle the expense of drying could be reduced considerably.

In utilizing other methods of drying, such as drying oven or specially designed drying machinery, it may be more expensive perhaps due to the initial cost of equipment; but should we take into account the effect on the cost of steam production we may find these methods to be more economical. It would be absurd, however, as far as economy is concerned to deal with questions of small economy when we have before us great questions of much greater economy. For this reason we shall consider drying as obtained by ordinary conveyors through the mediums of flue gases and exhaust steam, as will be mentioned in the other chapters. In these cases the possible saving is large, due to the fact that the apparatus is not special and therefore not costly; the medium is waste heat which again is inexpensive. This indicates the possible economy of outside furnace drying.

In considering the effectiveness of the process, it should be stated that although the furnace drying may be the most effective, due to its rapidity of action, it can not be as effective as is possible with outside drying. Inside the furnace the drying will depend on the time taken in sliding down the grate, which is quite difficult to regulate, as the boiler rating depends upon different circumstances. With outside drying we can dry as much as we want, thus making it possible to obtain more effective drying than in the furnace. In the furnace the quick drying due to the reflected and refracted heat does not mean effective drying, since outside drying with a longer time interval could reduce better the moisture per cent of the fuel. With atmospheric drying, or oven drying or any special drying apparatus it is possible to extract more water than can be done during the limited time the fuel is in the furnace. For these reasons, there is always greater possibility of obtaining more economical drying with the outside than with the inside furnace drying.

Utilization of Waste Heat

Utilization of chimney gases or exhaust steam for the purpose of drying the moist fuels is a very advantageous procedure. It obviates the need of fuel and even obviates the expenditure of the useful furnace heat, as when the fuel is dried within the furnace. The waste heat being at high temperature makes the drying effective, while its utilization as waste makes the drying process economical. Of course, both economy and effectiveness in drying will depend on the particular drying arrangement, but we are nowadays able to apply this method to our ordinary fuel conveyors thus drying the fuel while being conveyed into the boiler room. The use of a conveyor reduces the drying operation to the lowest possible cost, as its use obviates the initial expense of special drying apparatus. This method requires no labor, no special or extra installations, other than the small addition of jackets to the conveyors. The only extra working expense is a blower or fan for driving the gases through the system. Taking into consideration then, the cost of apparatus, working expense, and the cost of the heating medium, there is no reason why every moist fuel consumer should not take advantage of this method. For this reason, in order to show the possibilities of such arrangements, it will be interesting to consider a few conveyors for this purpose.

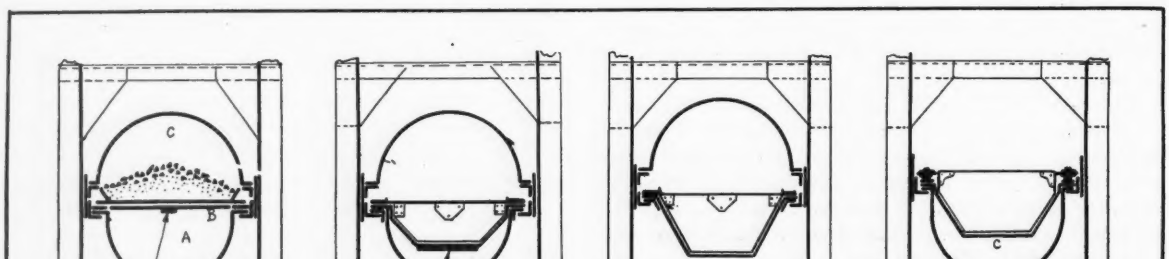


FIG 3-6. SECTIONS THROUGH VARIOUS TYPES OF CONVEYOR DRIERS

Classification of Drying-Conveyors

Because of the lack of demand, conveyors for drying have not been developed to any extent until quite

recently. Certain manufacturers, it is true, have done some development work but only on a small scale. Such apparatus may consist of nothing more than an ordinary type of conveyor fitted with either one or two jackets for holding the chimney gases or exhaust steam, while the arrangement of these jackets will depend on the type of conveyor. These drying-conveyors can be classified under two types: first, the drying conveyors permitting the gases to come in direct contact with the fuel; and second, the drying conveyors that heat the fuel by conduction through a metallic plate.

Considering the first case, where the conveyed fuel and chimney gases are enclosed in one compartment, this has the advantage of mixing the gases with the fuel and thus producing an intense heating that results in an effective evaporation. Moreover the draft from the special fans and that of the chimney produces a vacuum that helps much to increase the evaporation of the water within the fuel. In addition to these features the fuel being in contact with the gases becomes well heated before entering the furnace and thus requires fewer calories for being brought to the ignition temperature. The only disadvantage is that it can use only chimney gases and not exhaust steam.

In the second case, where the heating element is enclosed in a separate chamber under the conveying trough, it has the advantage of simplifying the conveying apparatus and reduces some of the difficulties met in connection with the charging and discharging of fuel usually somewhat complicated with the former types. Moreover it permits to take advantage of heating with either chimney gases or exhaust steam, and makes the drying independent of the fuel conveyed. For simplicity of discussion, however, we will classify the drying conveyors as to their heating efficiencies. In this case, they may be divided under two types, first, those conveyors in which the drying is done by mixing the gases with the fuels and second, conveyors that do the drying only by contact.

Effective Drying by Mixing Gases with Fuel

Drying by direct mixing of chimney gases with the fuel was at first applied only to specially made drying apparatus. In order to follow the application of such principle of drying, it is interesting to give a brief account of one of these modern types of driers that proved highly successful. Figure 1 shows a diagram of a drier of a type in common use today. In this apparatus the drum A is stationary and is covered throughout its whole length by a wire gauze sheet. The drum B consists of a solid cylinder, turning slowly around its axis by worm gears. The gases admitted into A^1 in passing through the gauze sheet come in contact with the fuel contained in the larger drum B. This drum has on its interior surface a large spiral so as to turn the fuel and to mix it well with the hot gases for effective drying. These gases are exhausted by a fan and delivered into the chimney. This principle of drying is generally applied to the drying conveyor when effective drying is required. It may be applied to any type of conveyor; that is, either platform or scraper type. With both types, the gases are made to pass through the fuel mass, so as to evaporate the greatest possible water from the fuel.

When this principle is applied to the platform type of conveyor, the platform is neither of wood nor of belting, but since they must sustain high temperatures they are usually of metallic slat type. In this case, however, the gases must pass the fuel layer, and apertures between two adjacent slats, A B, Fig. 2, are made open or close according to the quantity of gas required for drying. Such a conveyor, completely installed, is shown in Fig. 3, in which case the gases are charged into the pocket A, and pass between slats B, entering the jacket C from where they are drawn into the chimney flues. The principle of operation is similar to that shown in Fig. 1, and is therefore highly effective. Considering the scraper type of conveyor, this principle may be applied with success when working in only one direction. The type shown in Fig. 4 resembles that of Fig 3 very much, having the only difference that the stationary trough is made at the bottom in the same manner as Fig. 2.

Drying Fuel by Contact in Conveyors

While the drying of fuel by contact is not as effective as the above described methods it has the advantages of using equipment much simpler in construction than that giving the mixing effect. It obviates the need of the double jacket, and also the use of complicated trough-bottoms.

Methods in which fuel is dried by contact are of two distinct types, first, those in which the gases themselves are in contact with the fuel, and second, those in which the fuel is in contact with a metallic plate heated by the gases or exhaust steam. Considering the first of these the system shown in Fig. 5 is an ordinary scraper, the trough of which is only covered with a jacket so as to draw out the gases into the chimney. It is the only type of drying conveyor that has the advantage of permitting the discharge of fuel at any desirable point or desirable points.

This type of drying conveyor is much more effective when the prong type of flights are attached instead of the ordinary flat type. This type permits the gases to come in better contact with the fuel due to the peculiar effect produced by the moving bars of the prong-flights.

In methods of drying by conduction, we meet with the simplest type of drying conveyor. In this case, the gases are enclosed in the jacket placed underneath the trough as shown in Fig. 6. The fuel pushed by flights is always in contact with plate C which absorbs the heat of the hot gases. This has the advantage of having the drying arrangement independent of the fuel conveying arrangement, and as being very easy to be installed in connection with any ordinary scraper conveyor.

Such a type of conveyor can be conveniently operated on exhaust steam. This may be done regardless of whether a condenser is used or not. If a condenser is used the pipes from the end of the jacket may communicate with the condenser and the jackets may be covered with insulating material so as to prevent rapid cooling of jackets by the atmosphere.

A Special Case

In Fig. 7 is shown a battery of boilers with moist fuel transporters installed at the rear. This is the arrangement employed at the large sugar refinery for conveying bagasse. While this arrangement is not the most suitable, its design was dependent to a large extent upon the location of the sugar mill at the rear, and no other means

was available for connecting the conveyors. The heat radiating from the furnace brickwork, however, keeps the narrow passage at a higher temperature than in any other part of the factory. This heat materially assisted the evaporation, and it was found that the effect was of an interesting nature. Of course the particular action depends upon a number of conditions such as fuel, furnace condition, rating, inside temperature, brickwork conditions, etc., and before giving an idea of the effect it may be stated that this fuel is one of such nature that it actually requires less heat units in drying than that theoretically necessary. This is due to the evaporation of water in the vascular state.

With this arrangement and fuel, the moisture in the fuel may be reduced to about 5 per cent of its original value. With respect to the gain in fuel we find that the original moisture content of 53 per cent is reduced to 50.35 per cent. The value of the fuel at 53 per cent is

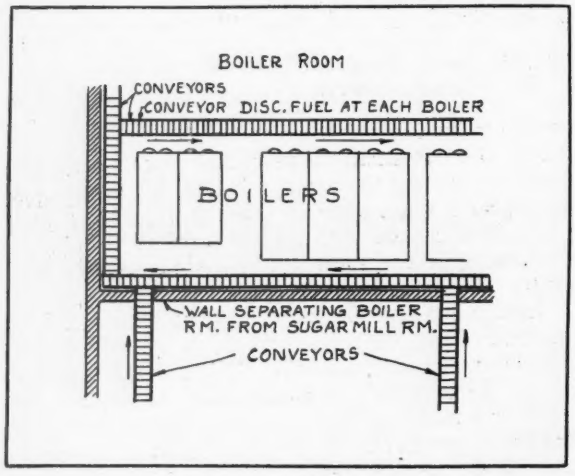


FIG. 7. PART PLAN OF BOILER ROOM IN A SUGAR REFINERY SHOWING CONVEYORS

4.56 kg. for one kilogram of good Cardiff coal, while at 50.35 it is only 4.215 kg., therefore it results in a gain of $4.56 - 4.215 = 0.345$ kg. for every 4.56 kg. of fuel at 53 per cent of original moisture content.

Conclusion

From the foregoing, it is evident that due to the low cost of the drying arrangement, it is possible to make a great saving by drying the fuel externally. Should it be impractical to carry this drying process out entirely in this manner, it will in most cases pay to dry the fuel partially in this manner and to remove the rest of the moisture within the furnace. The question of economy with the use of these conveyors is well assured, as it requires only a small initial cost and a low operating cost. When using the hot gases the slight expense of the working of the fans could be still further reduced, as the chimney or forced draft apparatus are already acting as exhausters and the conveyor can be arranged in such a manner as to take advantage of this draft. We have also demonstrated how economy could be best obtained through these methods of drying by illustrating a gain of 7.5 kg. per every 100 kg. of fuel by simply placing the bagasse conveyor in the described position.

Purchased Power Proves Expensive in Hotel

Steam Requirements for Heating Water in Hotel Reflect the Personal Habits of the Guests

IN 1919 IT BECAME evident that the Gibson Hotel in Cincinnati would be enlarged to practically twice the size it was at that time and as the question of purchasing power had been up for consideration a number of times, it was decided to enter into a contract with the local public service company to supply electric current

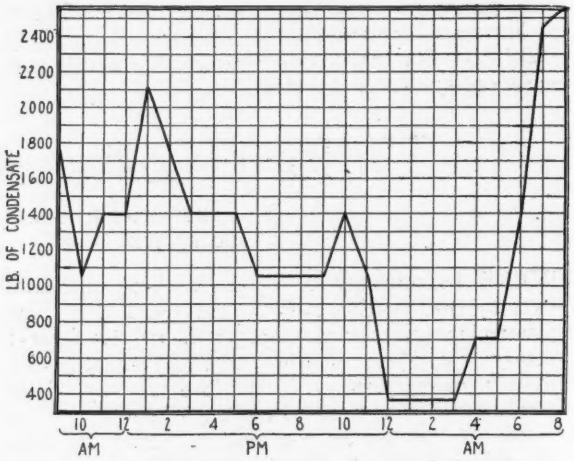


CHART SHOWING VARIATION IN USE OF STEAM THROUGHOUT 24 HR.

for power and lights in order to arrive at a direct comparison of cost of operating the existing power plant when generating all the electricity used and when the electricity was purchased.

As a result of this decision a contract was secured for one year and the hotel began using central station power on November 1, 1919. At the end of the following year a careful checkup of the expenses for running the plant showed that by purchasing the power the expenses had increased $2125 above the preceding year, all corrections having been made to make a just comparison.

Coal costs were taken at an average of $4.25 a ton and the average cost of current for the year was 1.46 cents per kilowatt-hour. The total power consumed for the year 1920 was 1,517,130 kw.-hr.

On the basis of the results secured during this experiment, it was decided to continue generating power in the hotel plant and a new generating unit was made part of the equipment of the addition to the power plant.

As in every hotel, a great amount of steam is used at low pressure for heating the house and the water for domestic purposes and it is through the loss of the exhaust steam from the generating unit that the purchased power is more expensive. When power is purchased from outside, it becomes necessary to use live steam at reduced pressure a greater share of the time, as there is not sufficient exhaust steam from the other equipment to supply the needs of the hotel except for a portion of the year.

To determine the amount of exhaust steam required for heating the house water, a test was run on Oct. 28,

1919, weighing each hour the amount of condensate collected in the water heater. This test was made when the hotel was accommodating 550 guests, practically every room being occupied. The temperature of the water entering the heaters was 69 deg. F. and left them at approximately 160 deg. F. During the 24 hr. of the test 29,510 lb. of steam were used, the hourly variation being shown in the accompanying curve. Alberger closed heaters are used for this purpose and the steam pressure carried was approximately ¾ lb. gage, the condensate being drawn off by a vacuum pump.

In the old plant are three 300-hp. B. & W. boilers served by Murphy stokers and developing steam at 125 lb. pressure. West Virginia nut and slack coal is used having a heat value varying between 13,500 and 14,000 B.t.u. For handling the coal and ash in the plant a mono rail system is provided.

Two 200-kw. direct current Triumph generators driven by 16 by 30-in. Hamilton Corliss engines furnished the power and light used in the old hotel.

Refrigeration is supplied by a 35-T. Triumph compressor driven by a Hamilton Corliss engine with a 10-T. compressor used as a stand-by. Other steam driven equipment consists of the boiler feed and vacuum pumps. Except for a few months during the summer, all of the exhaust steam from these engines and pumps is used for domestic purposes. The house pump, air compressor and all elevators are electric driven.

In order to serve the new section of the hotel, which has just been opened, there has been added to the power plant equipment mentioned above a 375-kw. G. E. d.c. generator driven by a 22 by 30-in. Hamilton Corliss engine and a 450-hp. B. & W. boiler served by a Jones underfeed stoker.

Uniform Costs for Power Plants---I

IT IS IMPOSSIBLE TO OPERATE A POWER PLANT WITHOUT AN ADEQUATE COST SYSTEM. BY ALFRED BARUCH

THERE IS probably no other phase of industrial activity that requires accurate cost keeping so much as power plants whether they are public utilities or serve a factory or group of factories. The bulk of the investment in a power plant, and therefore the bulk of the charges against it, is fixed. Insufficient knowledge as to the cost of the service rendered is likely to cause irreparable damage. A manufacturing plant may come through unscathed because a bad year was followed by a good one or because a kindly tariff enabled even the inefficient producer to make a profit. A power plant has no such protection. Its owners must operate with the assumption that the best they can do is to run the plant to full capacity and in this way make a revenue producer out of every part of the plant. However, it is clear that there will be times when there is a heavier demand on the station than usual and the plant must have sufficient equipment to meet the demand. But when the load drops, some of the equipment is bound to be idle or at least not used to its full capacity and it is therefore necessary to have complete information as to the cost of operation so as to know how much to charge at peak load to meet the losses that are sure to be incurred when the load drops.

Fluctuating demands for service in a power plant compels the operator to maintain on hand at all times in good running condition enough equipment to meet the maximum demand. In addition to these charges, the power plant is subject to the same increase and decrease in activity that is common to the manufacturing world which uses less current when business is poor or out of season. Thus the power plant has to keep enough equipment on hand to care for the needs of factories at the very height of business activity.

In this way only a highly efficient operator can make money in times of general depression. Efficiency is defined as the ratio between the effort expended and the results obtained. In other words, an operator must get back more money than he puts in order to be efficient. This is obvious, but the way to do it is not so clear. Some factors, such as general business conditions are beyond the operator's control, but the great majority of them are in his own hands and he can alter them to suit himself. He can eliminate waste and he can avoid the mistake of putting too low a value on the service. A cost system is a great aid in either case. As a matter of fact, it is impossible to operate a power plant without a cost system of some sort or without periodic cost surveys.

Cost systems make for intelligent competition. There is no field of business activity where the punishment for ignorant cut-throat competition follows as quickly as it does in the operation of public utilities. That is the reason why many operators prefer to have a monopoly with strict government supervision which even goes so far as to fix the rates rather than be subjected to competition that often leads to a choice between selling the service below cost and having to charge off the entire cost of operation as a loss. There is no excuse for the existence of this condition. However, the only legal way to avoid it is through the adoption of uniform cost methods. These tend to level prices automatically since two efficient plants of about the same size will carry about the same burden. The inefficient operators will be the only ones affected by uniform costs. They will be forced to change their methods or shut down.

LABOR RECORDS

Any power plant is a service unit. Accordingly it has not productive labor with which to deal and the unusual labor problems are lacking; however, the power plant labor is a very important part of the cost, and since the power plant renders more than one kind of service, it is necessary to have a very accurate distribution of the labor. There are certain portions of works in connection with the power plant which correspond in many details with the labor problems in a manufacturing plant.

In order to understand the methods of handling labor costs in this system, a list of the labor classifications in a power plant is given below. For the central station these are:

1. Engineer.
2. Fireman.

3. Switchboard operators.
4. Oilers.
5. Maintenance crew.
6. Installation.
7. Repair.
8. Collection.

If there are any substations, there would be operators and oilers, and one man on each watch to take care of the steam boiler that furnishes the heat to the plant. An examination of this list will show at once that various methods of wage payment must be used and therefore various methods of reporting time and output. The engineers, oilers, and switchboard operators must be paid by the hour since they cannot increase the output by their own efforts. The firemen, installation men, meter readers and collectors can be paid on the unit basis. These two groups represent the fundamental methods of wage payment.

There are only two: the first is to pay for a man's services during a fixed period of time; the second is to pay for producing a unit or piece regardless of the time it takes. These two methods are known as the day wage, and the piece rate plan, respectively. The day wage plan is usually represented by a fixed price per hour and the piece rate plan by a fixed price per piece.

The difficulty with the time payment method is that there is no direct connection between the amount of work done and the wages received. A man is hired to put in his time and it is up to the foreman to see that he does not shirk. If there is a labor shortage, the worker may soldier on the job and still run no risk of losing it. Wherever the wage system is used as a substitute for the piece rate plan, supervision must be proportionately greater because there is no fair method by which a man can be penalized for not doing as much as is expected of him. As soon as this is done, the wage payment method becames a modification of the piece rate plan. There are certain classes of work, however, that must be put on a day rate basis even where the men do manual work and their output depends on their own efforts. For example, many public utilities operate a repair department as a service to the public as well as to their own plant. The jobs that come to this department will be so varied in their nature that it is practically impossible to establish a piece rate in advance.

Wherever it is possible to use it, the piece rate method is preferable since it is fair both to employers and to employes, provided both parties act in good faith. The simplicity of the method is one of its strongest recommendations. It automatically takes into account the difference between workers so that the most skilled will get the highest reward. It requires less supervision than the other method. But it also has some disadvantages. In the first place, most men do not know how to set a piece rate properly if they do not maintain the necessary production records or make time studies. They cannot determine with any degree of fairness to themselves and to the workers, how much a man can do in one day, and therefore how much he should be paid per piece in order to earn a fair wage. Another objection to this method in the past has been that employers have cut the rate as soon as they saw that their workers earned more than the customary wages. If the rate is too high at the beginning, it is usually the employer's fault for not getting the proper information before setting the rate. Nothing antagonizes the worker more than having his wage rate cut after he has managed to increase production by extra effort. He feels that he has been betrayed into working for less money at top speed.

Two usual methods for developing these records are time reports and stop watch studies. F. W. Taylor, when he was with the Bethlehem Steel Company, showed the way to increase production by means of time studies. His first step was to remove all possible obstacles from the path of the worker. All supplies and equipment were arranged before so that there could be no delay for the moulders or coremakers. For example, the moulders did not pour off their own castings, but went on making moulds while the metal was being poured by a less skilled and lower paid man. Then each man was taught the operation he was to perform. After he has been thoroughly trained and arrangements made so that he could work under the best possible conditions, time studies were made and piece rates were based on them. The same thing can be done by substituting production records for stop-watch observations.

The method of wage payment that has been adopted in many plants with a great deal of success is the task with a bonus. It is mentioned here because it is particularly applicable to the boiler room, in paying hand stokers. It is a combination of the two primary methods. The men are assigned a task. If they fulfill their task, they get paid full wages. If they exceed the task, they get paid a bonus of approximately 30 per cent. For example, a stoker may be instructed to keep steam up to a certain pressure within the limits set down by experience and practicability. The pressure curve is shown by a Bristol chart. The stoker is given a bonus for the extent to which his variation in pressure fall within the margin allowed by the engineer. Although this is not the place for a discussion of the subject, it is a fact that boiler rooms employing hand stokers use about 20 per cent more coal than is needed due chiefly to the custom among stokers to load the furnace full and get up high pressure and then wait until the fire has almost burned out and the pressure dropped before stoking again.

Labor Records

Labor records have two important functions: the first is to establish the cost of production; the second is to account for labor time and wages. The first feature provides the basis for predetermining the cost of production and thus permitting the price to be set. The second furnishes the basis for the payroll. Consequently, the mechanism that is devised to secure the information as to labor operations and payroll must have these two functions in view. Aside from this, the only other consideration is the way to design a set of records that will be suitable to power plants.

Where day-wages are paid exclusively, it is possible to register the length of time the men are on the premises by installing a time-clock or any of the other devices now in use. The chief function of the time clock at present is that of an aid to discipline. It creates a record which shows what time each man arrived on the job. Where men are paid by the day wage plan, this is important since they are really being paid for the time they put in. In a power plant, it is especially important because the men usually work by watches and a man who is chronically late can become a source of great annoyance to the men he relieves. The clock card can

also be used as the basis for the payroll when men are paid on the hourly basis and it is not necessary to know what they did during that time—as an operator in charge of a switchboard who must be there for the plant to run. The same would be true of oilers.

This method, however, will not do for the repair department where it is necessary to know the amount of labor on each job. In recording labor in this department, we have a choice of two methods which depend upon the nature of the work done in each shop for their practicability. The first is the daily time card which lists the jobs worked on and the time spent on each one. The heading shows the name of the man, the date and his department. The body shows the serial number of the device he is repairing, the order number, the elapsed time, the number completed, if there are more than one. The bottom shows the rate, the total pay, and the timekeeper's check. Sometimes the edge of the card carries a time scale so that the clerk may punch the length of time that the job takes.

A second method of keeping time is referred to as the job card system. As its name implies, it reports a separate job on each card. In this way it is possible for a man to have two or more reports to fill out each day if he has two or more jobs to do. Of course, this method presents a more accurate labor record since a man holds only one card at a time and there is no opportunity to overcharge one job and under-charge another. As the job cards are identified by order numbers, all that is necessary to find the labor charges against any particular job is to sort the cards according to their order numbers and file them. This card must show the worker's number, his bench or machine number, the order number, the date, the quantity completed, if the job consists of more than one unit, the total elapsed time, and the foreman's check.

This method may be made very simple by having the timekeeper distribute all the jobs. In that case the procedure would be as follows: When a man finishes a job, he brings the job card to the timekeeper who notes the elapsed time and then issues a new card for the next job. This card now shows the starting time of the job. A variation of this method may be found in the time distribution sheet in which the men's names are listed in a vertical column at the left-hand side of the sheet and the jobs are entered at the heads of the columns across the top of the sheet. The time spent on each job is marked on the line with the man's name under the job number. By adding all the time charged to jobs on a line with man's name, the total time he works that week can be found. By totalling at the foot of the page all the time charged in column under a job number, it is possible to find the number of labor hours for each job for the week.

Payroll Distribution

In the foregoing, care is taken of charges to individual jobs and of the time each man works. In addition, distribution must be made of the time so as to show the amount of labor chargeable to each department. This is done by summarizing the various labor reports on a payroll sheet, specially designed to suit the needs of the power plant. This sheet contains each man's name and his clock number. These hours are totalled horizontally and in the next column, multiplied by the rate so as to give the wages due to him at end of the week. The remainder of the sheet is divided into columns indicating the distribution of time such as office salaries, general labor, boiler room labor, transformer department, installation department, repair department, etc. These columns are totalled at the bottom and their sum should equal all salaries and wages paid that week. This information is kept in a special loose-leaf book and does not make a part of the general books. The only entries to be made in the general ledger is a charge to the payroll account and a credit to cash. In those departments where the time sheets are used, as explained above, some time may be saved by treating these sheets as a part of the payroll distribution and not copying them. In that case, they would have to be printed on the same size sheet as the payroll so that they could readily be filed in the time book.

In the preceding discussion we have presented all the available methods for getting the labor costs. It is not advisable for the men to fill out their own time reports. They usually resent doing any clerical work, and their reports are very unreliable, as a basis for cost. It is best to have the timekeeper make out the time himself. He is familiar with the work and can get an accurate report very quickly, especially if he uses the distribution of time sheets.

Budget Labor Costs

It is possible to place definite limits on labor costs beyond which hey may not go by establishing standards and measuring every department according to them. There are some departments in which the labor charge is fixed and no variation is customary, as in the case of the operating department where one operator and one oiler can take care of the entire equipment. But practically all the rest are predisposed to excessive labor charges if not properly watched, particularly the repair and installation departments. By establishing labor cost standards, each department is put upon a budget and the foreman must keep within its limits or give a written explanation for the deficit. Some of these causes are unavoidable, such as breakdowns, which result in no revenue being earned although the labor costs go on.

Another advantage to the budget method of keeping labor cost is that it enables the plant owners to anticipate unavoidable delays and breakdowns and to make due allowance for labor and other incidental expenses which naturally become a part of the burden, during these delays. By carrying records of sufficient accuracy, it is possible to introduce a charge for idle time which will cover all emergencies.

There is no definite size to which coal must be ground for use in powdered-coal burning plants, although it is recommended, generally, that 95 per cent of the pulverized coal should pass through a sieve with 100 meshes to the inch and 80 to 85 per cent through a sieve with 200 meshes to the inch, states John Blizard, fuel engineer of the Department of the Interior in Bulletin 217, just issued by the Bureau of Mines. It has been found possible to operate some furnaces with coarser coal, and found necessary for firing open-hearth furnaces to grind the coal more finely. The more finely the coal is ground the more rapidly will it burn, and the more readily will the smaller ash particles pass off with the gas. The power required to pulverize coal increases, however, with the fineness of pulverization.

Heaters for Hot Blast Work---II

METHODS FOR DETERMINING HEATING SURFACE FOR HEATING PLANTS IN PUBLIC BUILDINGS AND INDUSTRIAL PLANTS. BY CHARLES L. HUBBARD

WHEN HEATING apparatus is located in the basement, a solid foundation of brick or concrete is usually constructed, upon which angle or tee bars are placed for carrying the heater bases. In standard makes of heaters, the under side of each base at the steam supply end is usually provided with a groove into which the supporting angle-iron fits, thus holding them in line and serving as an anchor, while the other end is left free to expand and contract with changes in temperature. Heaters may be placed upon any concrete floor which is sufficiently strong to support them, by building piers for the angle-irons to rest upon so as to give sufficient height above the floor to make the return connections.

In shops and factories, cross-bracing is often put between structural steel beams and a flooring of heavy steel plate provided for the fan and heater to rest upon.

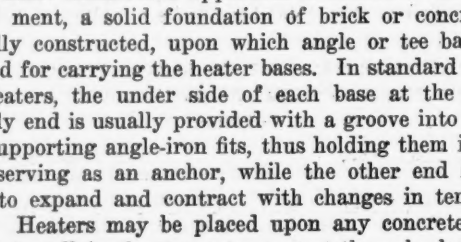


FIG. 1. COMMON ARRANGEMENT OF HEATING COILS AND FAN SHOWING USE OF BYPASS DAMPER TO SHORT CIRCUIT COLD AIR AROUND COILS

Local conditions will decide the best form of support to use and steel and concrete are often combined for this purpose.

BYPASS DAMPERS

MENTION HAS been made of regulating the air temperature by manipulation of the steam and return valves, thus varying the number of sections in use. A more convenient method, and one that is frequently employed with automatic regulation, is to provide a bypass damper, by means of which a varying proportion of cold air may be sent around the heater, and mixed with the heated air beyond, thus cooling it to the temperature desired. With this arrangement, a sufficient number of sections are turned on to heat the air to a point slightly above the maximum required for the day, or for that particular period of the season, and the finer regulation, which is necessary from hour to hour, is secured by setting the bypass damper so as to give the proper mixture beyond the heater to produce the desired temperature. When automatic service is available, approximate regulation is secured by means of the steam valves, and the final accurate regulation by attaching a duct thermostat, of the graduated type, to the bypass damper. Sometimes the bypass is simply a door between the cold-air and fan rooms, with means for holding it in any intermediate position between closed and wide open. Usually the bypass opening is either over or beneath the heater, with an adjustable damper of the general form shown in Fig. 1. Very large dampers are generally divided into sections like a blind or louvre, which makes a stiffer construction and one less liable to rattle.

DETERMINING SIZE AND PROPORTIONS

CAPACITY OF a heater is affected by the depth, the amount of heating surface, the velocity of air flow over the pipes, and the difference in temperature between the heating surface and the air.

Final temperature increases with the depth, while the heat transmission per square foot of surface is reduced. Changes in velocity have the reverse effect; that is, increasing the rate of air flow reduces the final temperature, but increases the total heat transmission per square foot of surface. Varying the temperature difference between the heating surface and the air, affects both the final temperature and the rate of transmission. The first step in computing the size of a heater is to determine the volume of air to be supplied, and its initial and final temperatures. For work of this kind the standard formula is $H = V \times T \div 55$, in which H is the heat required, per unit of time, in B.t.u., V, the cubic feet of air heated, and T, the total rise in temperature, in degrees. The use of this formula in practical work is best illustrated by solving some of the examples most frequently met with in the heating and ventilation of various types of buildings.

(1) What quantity of heat will be required to warm 50,000 cu. ft. of air per min. from zero to 70 deg.?

$H = 50{,}000 \times 70 \div 55 = 63{,}600$ B.t.u. per min.

(2) What volume of air will be required to transmit 500,000 B.t.u. per hr. to a building, by raising its temperature to 20 deg. above the normal inside temperature? Or, put in another way, the heat loss from a building, with a given minimum outside temperature, say zero, is 500,000 B.t.u. per hr., due to transmission through the building walls and leakage, when the normal inside temperature is 70 deg. How much air will have to be supplied per hour at a temperature of $20 + 70 = 90$ deg. to offset this loss and keep the building warm?

$V = 500{,}000 \times 55 \div 20 = 1{,}375{,}000$ cu. ft.

(3) A building is to be supplied with 2,000,000 cu. ft. of air per hr. for ventilating purposes, at a temperature of 65 deg. How much must the temperature be increased above this to bring in 800,000 B.t.u. per hr. for heating purposes, so as to do away with direct radiation and do both heating and ventilating from the main heater?

$T = 800{,}000 \times 55 \div 2{,}000{,}000 = 22$ deg., and the air must be delivered to the building at a temperature of $65 + 22 = 87$ deg.

(4) A shop building is to be heated to a temperature of 60 deg. in zero weather by recirculation of air through the fan and heater without taking any in from the outside. The air is to leave the fan at a temperature of 140 deg. and is to be returned to the heater at 50 deg. The total heat loss from the building, by transmission and leakage under these conditions, is 640,000 B.t.u. per hr. What volume of air will it be necessary to pass through the heater?

In cooling 1 deg. 1 cu. ft. of air gives off $\frac{1}{55}$ B.t.u., and in cooling $140 - 50 = 90$ deg., it will give off $90 \times \frac{1}{55} = 1.6$ B.t.u., therefore, $640{,}000 \div 1.6 = 400{,}000$ cu. ft. of air per hr., is the amount which must be circulated per hour under the assumed conditions. The temperatures assumed in this example represent those commonly employed in actual practice.

Having seen how to determine the quantity of heat to be supplied in any given case, and the final temperature required under different conditions, the next step is to design a heater to fulfil the various requirements.

Design of Pipe Heaters

Free area for the flow of air through a pipe heater will vary slightly in different cases, but will commonly run from 0.4 to 0.5 of the superficial area. That is, a heater 5 ft. wide and 6 ft. high above the base, will have a free area for the flow of air of approximately $5 \times 6 \times 0.4 = 12$ sq. ft. When the make and type of heater to be used is known, the actual free area for any given size of section may be obtained from the catalog.

The most desirable velocity to employ will depend partly upon the depth of the heater and partly upon the type of building. In schools, office buildings, public institutions, etc., where quietness of action is essential, lower velocities are employed than in manufacturing plants. Table I gives about the average employed in the two classes of buildings.

TABLE I. ALLOWABLE VELOCITY THROUGH HEATER IN PUBLIC BUILDINGS AND IN INDUSTRIAL PLANTS

	Velocity through heater, in ft. per min.	
Rows of pipe deep	Public buildings	Industrial buildings
4 to 8	1200	1500
12 to 20	1000	1200
24 to 32	800	1200

These figures are to be used as a guide, and are subject to more or less change in proportioning the heater to meet various conditions. In general, they should be reduced rather than increased to any extent, when changes of this kind are made.

One of the conditions to be provided for in all cases is the final air temperature, as this is dependent upon the depth of heater and is based upon actual tests of the various types of heaters used, for different steam pressures and velocities of flow. Heaters for use in the Middle West and New England are usually designed for a minimum outside temperature of zero, and Table II is computed for this condition, based on a steam pressure of 5 lb. gage; it applies to heaters of the loop or mitre types. For steam at atmospheric pressure, when used with a vacuum system, multiply the final temperatures and efficiencies given in this table by 0.9. With the return-bend type of heater, the figures in Table II should be multiplied by 0.7 for average conditions.

Example: Computations show that a public building requires 1,800,000 cu. ft. of air per hour, which must be raised to a temperature of 115 deg. to warm the building in zero weather. How many square feet of surface should the heater contain, what should be its depth (in rows of pipe), and superficial area?

Referring to Table II, we find that a heater 16 pipes deep will raise the temperature of air from zero to 116 deg., with a velocity of 1000 ft. per min., and give a transmission factor of 1700 B.t.u. per sq. ft. of heating surface per hr. The total heat to be supplied is $1{,}800{,}000 \times 115 \div 55 = 3{,}800{,}000$ B.t.u. (nearly) and at the rate found will require $3{,}800{,}000 \div 1700 = 2230$ sq. ft. of heating surface. Trade catalogs relating to the loop type of heater indicate that a 4-row section with a base 5 ft. long and pipes 7 ft. high contains 277 sq. ft. of heating surface. Taking two of these sections and placing them side by side will give a superficial area of $(5 + 5) \times 7 = 70$ sq. ft., or a free area of approximately $70 \times 0.45 = 31.5$ sq. ft. With a velocity of 1000 ft. per min., this will give a supply of $30 \times 1000 = 30{,}000$ cu. ft. per min. or 1,800,000 cu. ft. per hr., which fulfils the requirements of the problem. A 4-row section of this heater contains $277 + 277 = 554$ sq. ft. of surface, and 16 rows would contain $554 \times 4 = 2216$ sq. ft., which is practically that called for. If steam at atmospheric pressure is to be used, with a vacuum, 20 rows of pipe would be necessary, which would give a total temperature of $131 \times 0.9 = 117$ deg., and a transmission factor of 1500 B.t.u., calling for $3{,}800{,}000 \div 1500 = 2530$ sq. ft. of surface.

TABLE II. FINAL TEMPERATURE AND RATE OF HEAT TRANSFER FOR STEAM PIPE HEATERS WITH VARYING AIR VELOCITIES

Outside Temp. 0 deg. Steam Pressure 5 lbs.

Rows of pipe deep	800 ft. vel.		1,000 ft. vel.		1,200 ft. vel.		1,500 ft. vel.	
	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.
4	45	2100	42	2450	38	2700	34	3000
8	77	1800	73	2150	68	2400	61	2700
12	102	1600	97	1900	91	2150	83	2450
16	120	1400	116	1700	110	1950	102	2250
20	135	1250	131	1500	126	1750	117	2100
24	147	1150	143	1400	139	1600	131	1950
28	157	1050	153	1300	150	1500	142	1800

For hot-water heaters of the mitre type, with an average water temperature of 180 deg., data given in Table III may be used.

Design of Cast-Iron Heaters

Data given in Table IV refers to heaters of the cast-iron pin type. These units are made in different sizes and assembled with varying spaces between the sections, so that data relating to heating surface and free area should be obtained from the catalog for the particular size of section to be used.

Table IV gives data for the regular sections, 9⅛ in. wide, spaced 5 in. on centers, which correspond, approximately, when made up in the stack, to a pipe heater, 4

TABLE III. FINAL TEMPERATURES AND RATE OF HEAT TRANSFER FOR HOT WATER HEATERS WITH VARYING AIR VELOCITIES

Outside Temp. 0 deg. Average Temp. of Water 180 deg.

Rows of pipe deep	800 ft. vel.		1,000 ft. vel.		1,200 ft. vel.		1,500 ft. vel.	
	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.
4	31	1500	29	1700	27	1900	25	2100
8	55	1300	53	1500	49	1700	45	1900
12	74	1150	70	1350	67	1500	62	1700
16	88	1000	85	1200	81	1350	77	1550
20	101	900	97	1100	94	1250	89	1450
24	111	800	108	1000	104	1150	99	1350
28	119	700	117	900	113	1050	108	1250

rows deep, of the same superficial area, so far as heating surface, free area, and depth are concerned.

TABLE IV. THERMAL CHARACTERISTICS OF CAST IRON STEAM HEATER FOR DIFFERENT AIR VELOCITIES

Outside Temp. 0 deg. Steam Pressure 5 lbs.

Number of sections deep	800 ft. vel.		1,000 ft. vel.		1,200 ft. vel.		1,400 ft. vel.	
	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.
1	38	1875	35	2100	32	2350	.....	.....
2	68	1675	62	1900	58	2150	54	2325
3	93	1525	86	1750	81	2000	76	2150
4	113	1400	106	1625	100	1850	95	2000
5	129	1275	122	1500	115	1700	109	1875
6	143	1175	135	1400	129	1600	123	1750
7	154	1075	147	1300	140	1500	135	1650
8	164	1000	156	1200	150	1400	144	1550

The use of this table is practically the same as that of the pipe heater which has been illustrated by a working example.

Table V is for the same form of heater as in Table IV, but supplied with hot water at an average temperature of 180 deg. instead of steam.

Resistance to Air Flow

Frictional resistance to air flow through a heating or ventilating system of the hot-blast type is an important factor in determining the speed of fan and the power necessary for driving it. Usually the static pressure for forcing the air through the system is expressed in in. of water column, and may be taken approximately as follows for different types of buildings with the equipment and velocities commonly employed: Public buildings, without air washers, ½ to ¾ in.; with air washers, ¾ to ⅞ in. Shops and factories, without air washers, 1 to 1¼ in.

TABLE V. THERMAL CHARACTERISTICS OF CAST IRON HOT-WATER HEATER FOR VARYING AIR VELOCITIES

Outside Temp. 0 deg. Average Temp. of Water 180 deg.

Number of sections deep	800 ft. vel.		1,000 ft. vel.		1,200 ft. vel.		1,400 ft. vel.	
	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.	Final Temp., deg. F.	B.t.u. per sq. ft. per hr.
1	29	1300	27	1500	25	1650	.....	.....
2	51	1175	48	1350	45	1500	42	1625
3	70	1075	66	1225	61	1400	58	1500
4	86	975	81	1125	76	1300	72	1400
5	99	900	93	1050	88	1200	84	1300
6	109	825	103	975	99	1125	94	1225
7	118	750	113	900	108	1050	103	1150
8	126	700	121	850	116	975	111	1075

Average resistance for heaters alone, given in Tables VI and VII, are for the different types described, and vary with the depth, and air velocity through them. Table VI is for pipe section heaters, made up of 1-in. pipe spaced 2⅛ to 2⅝ in. on centers.

Friction through cast-iron heating stacks is given in Table VII. These figures are for the regular section spaced 5 in. on centers.

TABLE VI. FRICTION THROUGH PIPE HEATERS, INCHES OF WATER

Rows of pipe deep	Velocity in ft. per min.			
	800	1,000	1,200	1,500
4	.06	.10	.12	.20
8	.10	.16	.21	.33
12	.13	.21	.28	.44
16	.16	.25	.35	.55
20	.19	.30	.42	.66
24	.22	.34	.49	.77
28	.25	.39	.56	.88

The importance of data showing the frictional resistance is in determining the economical depth to employ when considering the cost of operating the fan. It is necessary, of course, to provide sufficient depth to give the necessary final temperature in the coldest weather, but any depth beyond this simply adds to the resistance against which the fan must operate, and runs up the horsepower quite rapidly.

TABLE VII. FRICTION THROUGH CAST IRON HEATERS, INCHES OF WATER

Number of sections deep	Velocity in ft. per min.			
	800	1,000	1,200	1,400
1	.037	.059	.084	.115
2	.070	.109	.157	.214
3	.103	.160	.230	.314
4	.135	.211	.303	.414
5	.167	.262	.376	.513
6	.200	.313	.449	.612
7	.232	.364	.522	.712
8	.265	.415	.596	.813

Pipe Sizes

Pipe connections should normally be proportioned to the quantity of steam condensed rather than the extent of heating surface. Referring back to Table II, we see that for a given depth of heater, say 20 pipes, the transmission factor will run from 1250 B.t.u. per sq. ft. of surface per hr. for a velocity of 800 ft. per min. up to 2100 B.t.u. for a velocity of 1500 ft. In order to cover this variation, Table VIII has been computed, based on the transmission factor of the given heater under maximum conditions of operation which may be taken directly from Tables II and IV. This applies to pressures of 1 to 5 lb. for all branch connections and for all mains up to 100 ft. in length. For mains between 100 and 200 ft. in length, use the next nominal size larger.

TABLE VIII. PIPE SIZES FOR STEAM HOT BLAST HEATERS

Steam Pipe	Gravity Return	Vacuum Return	Surface supplied for different transmission factors sq. ft.				
			Transmission Factor 1,000	Transmission Factor 1,500	Transmission Factor 2,000	Transmission Factor 2,500	Transmission Factor 3,000
2	1¼	¾	150	100	80	60	50
2½	1½	1	290	190	150	110	100
3	2	1¼	430	300	230	180	150
3½	2	1¼	670	450	350	300	230
4	2	1¼	900	600	480	400	320
5	2½	1½	1,650	1,100	850	650	600
6	3	2	2,900	1,900	1,500	1,100	1,000
7	3½	2½	4,400	3,000	2,300	1,800	1,500
8	4	3	6,300	4,200	3,300	2,500	2,200
9	4	3	8,200	5,500	4,300	3,400	3,000
10	5	3½	10,200	7,400	6,000	4,500	4,000

Example: What size main will be required to supply a pipe heater 20 rows deep, containing 3000 sq. ft. of surface, and taking air at a velocity of 1000 ft. per min.?

Referring to Table II, we find a heater 20 pipes deep, taking air at 1000 ft. per min. velocity, has a transmission factor of 1500 B.t.u. In Table VIII we find a heater having a transmission factor of 1500 and containing 3000 sq. ft. of surface, requires a 7 in. supply main, and a 3½ in. gravity return.

Stresses in Tubes for High Pressure Boilers

STEAM working pressures for water-tube boilers are being increased at such a rapid rate that many tables which show working pressures and fibre stresses for lap welded boiler tubes have become or will soon become inadequate.

Given herewith is a table prepared by L. B. Breedlove in which are shown maximum allowable working pressures in pounds per square inch, and the corresponding fibre stresses in pounds per square inch for lap welded boiler tubes; the fibre stresses are given in parenthesis. All figures are for commercial tube sizes and for stresses applied internally. The table is based upon the formula, $P = \frac{98{,}070\ t^2\ (1 - 0.10D)}{D}$, in which P equals the maximum allowable working pressure pounds per square inch, t equals the thickness of tube wall, inches, and D equals the outside diameter of the tube, inches.

TABLE SHOWING STRESSES IN TUBES FOR HIGH PRESSURE BOILERS

Outside Diam. of Tube (D)	Gauge number - B. W. G.												
	17	16	15	14	13	12	11	10	9	8	7	6	5
	Thickness (t) inches												
	0.058	0.065	0.072	0.083	0.095	0.109	0.120	0.134	0.148	0.165	0.180	0.203	0.220
1/2"	(2314) 627	(2600) 709	(2876) 966	(3310) 1502									
3/4"	(2250) 404	(2520) 511	(2800) 657	(3220) 834	(3700) 1097								
1"		(2450) 372	(2720) 457	(3130) 606	(3590) 796	(4130) 1081							
1-1/8"		(2410) 327	(2670) 396	(3080) 538	(3530) 698	(4050) 919	(4470) 1111						
1-1/4"		(2390) 297	(2650) 355	(3040) 466	(3460) 614	(3980) 806	(4410) 987	(4930) 1231					
1-1/2"			(2560) 286	(2960) 397	(3380) 499	(3840) 641	(4260) 798	(4780) 998	(5380) 1268				
1-3/4"				(2870) 318	(3280) 418	(3740) 547	(4150) 664	(4630) 848	(5120) 1001	(5720) 1258			
2"				(2790) 268	(3180) 352	(3640) 466	(4030) 564	(4500) 705	(4960) 860	(5540) 1065	(6080) 1270		
2-1/4"					(3090) 304	(3550) 405	(3910) 487	(4365) 609	(4810) 741	(5375) 920	(5840) 1093	(6400) 1286	
2-1/2"					(2990) 246	(3430) 345	(3780) 415	(4220) 518	(4640) 641	(5200) 800	(5640) 950	(6400) 1210	(6800) 1398
2-3/4"					(2880) 202	(3320) 298	(3650) 378	(4080) 446	(4500) 553	(5010) 687	(5470) 848	(6180) 1046	(6600) 1238
3"						(3210) 256	(3520) 324	(3940) 411	(4350) 507	(4860) 628	(5300) 748	(5970) 947	(6400) 1090
3-1/4"							(3400) 263	(3800) 326	(4200) 403	(4680) 516	(5100) 636	(5780) 864	(6210) 986
3-1/2"							(3290) 221	(3650) 276	(4030) 338	(4500) 422	(4910) 526	(5540) 705	(6005) 838
3-3/4"							(3180) 190	(3500) 236	(3850) 290	(4320) 360	(4730) 445	(5330) 579	(5720) 708
4"								(3380) 207	(3700) 251	(4150) 312	(4550) 384	(5140) 488	(5500) 607
4-1/2"									(3420) 161	(3800) 204	(4140) 252	(4690) 320	(5100) 392
5"									(3220) 207	(3660) 256	(3980) 317	(4580) 396	(4982) 474

A total of 536 public service generating stations in Great Britain is shown by the report of the "Electricity Commission" for the year ending March 31, 1922. Of this number 366 utilized steam as a source of power, 55 producer gas, 47 oil engines and the remainder other means, including water power. The Electrical Division of the Department of Commerce states that only seven stations depend exclusively upon water power, the largest of which produced 18,763,000 of the total of 29,107,000 kw.-hr., generated from this source. The total electric power generated during the year amounted to 4,884,666,038 kw.-hr. of which steam supplied power for for approximately 97 per cent.

Steps in De La Vergne Oil Engine Development

SOME OF THE FEATURES OF EARLY ENGINES WHICH HAVE INFLUENCED DESIGN OF PRESENT SOLID OR PUMP INJECTION TYPE

PROGRESS in the development of the solid or pump injection type of Diesel engine has been the result of gradual changes in design since the introduction of the first Diesel units. Some of these steps in the development are shown in the experience of the De La Vergne Co., which has led up to the introduction of its latest type SI vertical engine recently brought out in cylinder ratings of 65 and 100 hp.

In 1894 the first engine, known as the "Hornsby-Akroyd," was introduced from England and manufactured in this country for a number of years. Even today a large number of these engines are operating in cylinder sizes ranging up to 125 hp. per cylinder. In the Type HA engine fuel is injected through a spray or atomizing valve into an uncooled combustion chamber during suction stroke by a simple cam actuated plunger pump.

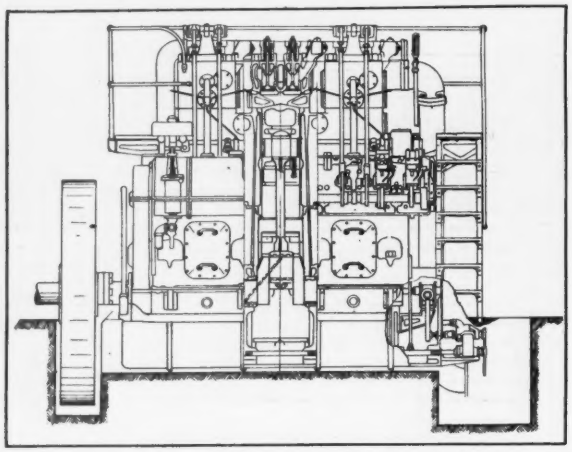


FIG. 1. TWO SPRAY VALVES ARE USED TO INTRODUCE THE OIL INTO THE COMBUSTION CHAMBER

The spray valve contains the spray plate in which are three to seven holes, depending on cylinder size, each hole about 0.015 in. diameter and a rather large automatic check valve seating against cylinder pressure but freely opened by pressure exerted by the injection pump. The vaporizer constituting a part of the combustion chamber is designed to operate at red heat when engine is carrying full load. This facilitates ignition and combustion of fuel spray or fog in a combustion space where compression is only 55 lb. Fuel economy at full load was initially 1.2 lb. per brake hp.-hr. and later was lowered to 0.9 lb. and finally to 0.75 lb., which was good economy for that period of oil engine development.

This engine, known as the "Hornsby," was one of the first successful four-cycle oil engines. As originally designed, it was limited to operation on rather light fuel oils and because of its low specific power and consequent heavy construction, another, the Type FH engine, was developed about 1907. In this engine, the compression pressure is about 280 lb.; a somewhat similar cam actuated fuel pump is used which injects the fuel into the vaporizer a few degrees ahead of compression dead center, atomization being effected by means of 1000 lb. injection air. It was the intention at the time this engine was developed to modify the existing type to operate on higher compression and use the pump injection features of the "Hornsby," but prevailing conditions necessitated resorting to use of high pressure air for atomization. The Type FH engine has a comparatively low fuel consumption of about 0.49 lb. per brake hp.-hr. and many engines today are operating on heaviest Mexican fuel oils. The specific capacity of the cylinder is greater and the character of fuel usable it will be noted includes practically any petroleum oil obtainable. This engine, however, requires use of high pressure air for atomization.

Subsequent development work logically therefore resulted in a third engine, the Type DH, which includes many good features of the preceding types and more nearly attained the original objective. This engine, first sold in 1913, however, requires the use of a vaporizer, although the latter is smaller and the average working temperature has been reduced to a low heat at full load. The Type DH engine does not have quite as low a fuel consumption as the Type FH, but its performance in using very heavy fuel oils and the satisfactory characteristics of the injection system logically led to the latest type of engine. In 1917 the first Type SI Diesel engine was introduced. In this engine compression ranging from 330 to 350 lb. if sufficient to ignite the fuel fog or spray without assistance of hot spots, vaporizers, or other similar means.

The latest De La Vergne engine, the vertical Type SI, is built in two cylinder sizes, one a 65-hp. cylinder, bore 14 in., stroke 18 in., and rated speed 277 r.p.m.; the other a 100-hp. cylinder with 17-in. bore and 24-in. stroke at 225 r.p.m. Both vertical engines are conservatively rated at an average m.e.p. referred to brake of less than 65 lb. per sq. in.

Certain distinctive design details as applied in this engine and which now seem so simple required much research and practical experience. These center largely in three features, the spray valve, combustion chamber, and the fuel injection pump with its cam and governor connections.

In Fig. 1 is shown a cross section of typical vertical cylinder construction. It will be noted there are two spray valves, one at each apex of two converging cones, constituting the combustion chamber, the latter connecting through a large rounded hole into the cylinder proper. The combustion chamber is completely water cooled. It is interesting to note that at one stage of development of the Type SI engine as many as six spray valves were used for atomization. The present spray valve includes a small spring loaded automatic check valve seating against cylinder pressures. Fuel oil is forced past the check valve through helical grooves along surface of a steel pin, thence through the spray nozzle. The hole in the latter varies from 0.032 in. to 0.05 in. diameter, the size employed being dependent on the character of fuel used.

Fuel injection pump cam with other co-related engine details as shown in Fig. 2 is shaped to start the pump

plunger about 20 deg. ahead of inner dead center and to accelerate the rate of plunger motion as the piston approaches inner dead center, after which the velocity of the plunger continues at steady speed. Actual fuel injection or atomization starts at about 12 deg. ahead of inner dead center. Success of the system centers in a steady, complete atomization with absolute sharp cutoff at end of injection. Cutoff is effected through a simple linkage connecting from the governor to actuate a small poppet or bypass valve in pressure side of the pump

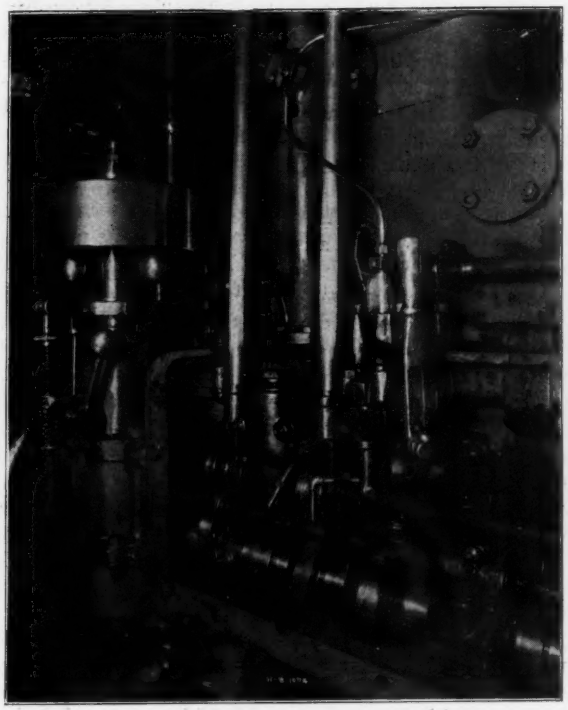


FIG. 2. FUEL PUMPS ARE OPERATED BY THE MAIN CAM SHAFT. GOVERNOR DRIVEN BY SKEW GEAR ON CAM SHAFT

chamber. When the bypass valve is suddenly opened, pressure is instantly reduced and any excess oil is bypassed back to the fuel supply tank.

In the fuel pump a bronze packingless type plunger reciprocates in a lap fitted plunger cylinder. Provision is made to drain any small fuel leakage past plunger back to the main fuel oil tank. The plunger is forced by a heavy spring against an aluminum guide. The latter mounts in substantial bosses a casehardened steel pin on which is carried a large roller. Reciprocating action of plunger is directly controlled by pump cam contour because of plunger spring pressure. The cam is of steel finished in a grinding machine exactly to duplicate a master cam, and is mounted on a cast iron hub section carried by a camshaft. Relative angularity or setting of cam may be varied to allow for wide variations in character of fuel used in the engine.

Fuel flows to the pump through a double set of suction valves and is discharged into the pressure fuel line through two discharge valves. These valves are in cages and all are interchangeable. Near the cylinder head, as will be noted from Fig. 2, the fuel line divides to connect to spray valves in the cylinder head. Provision is made so that any branch may be taken down independent of other connections.

Lubrication of the pump plunger guide and roller is taken care of by oil supplied through gravity sight feed gage from the main pressure lubricating oil supply system. Each pump is provided with a handle which is used for priming the pump and filling the fuel lines as well as the spray valves. The pump roller may be disengaged from its cam by means of a latch located in the pump handle. It is possible by this means to cut out cylinders as desired.

At the end of the engine on the frame facing is mounted a similar pump cam actuated. This delivers fuel oil from the main supply tank located outside engine room to a standpipe in which is a fine mesh fuel oil filter. Supply for the injection pumps is taken from and over-flow or excess oil cut off by the governor returned to the standpipe.

Study of Fig. 2 will indicate a simple flyball governor driven by a skew gear on the camshaft. The governor

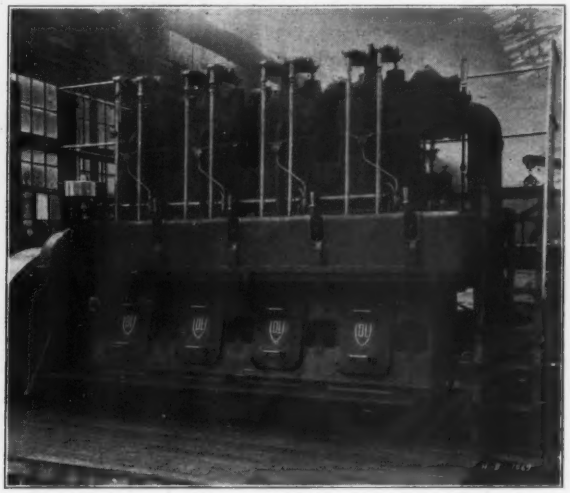


FIG. 3. SQUARE CYLINDER HEADS SIMPLIFY THE METHOD OF CONNECTING THE EXHAUST AND INLET AIR HEADERS

yoke lever through a link causes the control shaft mounted on cylinder jackets and running length of engine to rotate to a position proportional to load. This establishes point of cutoff for each fuel pump by changing position or pivot point of a link, the other end of which is oscillated by the plunger guide. Connecting to center of this link is another which operates a small lever on top of the fuel pump and thus opens the bypass valve by contact through a case hardened and adjustable set screw. The latter adjustment is made only when first tuning up engine or for any material change in fuel oil characteristics. Each cylinder has an independent fuel pump.

Engine features other than the above closely follow usual Diesel engine construction.

Exhaust and inlet valves are interchangeable and consist of a cast-iron body attached to a steel stem. These are arranged in removable and interchangeable cast-iron cages and close against cast-iron seats fitted to but removable from the cage proper. Provision is made to water-cool stem guides of the exhaust valves. Push rods actuate the exhaust and inlet valve levers for the smaller engine. The valve levers mount adjustable set screws to contact with steel pins inserted in valve stem ends.

Exhaust gases are carried out through water-cooled square sections on engine and thence to a point below floor by water jacketed piping. These header sections are supported on brackets attached to framing. Directly on top of the exhaust header is the air intake header which is connected by standard pipe to atmosphere outside engine room.

Low pressure air at about 100 lb. is all that is required for starting. During operation of the engine no air is used.

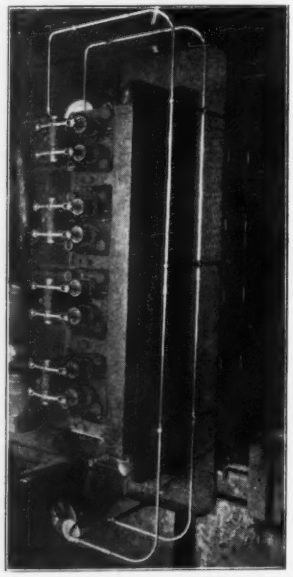


FIG. 4. EXHAUST, INLET AIR AND AN AUTOMATIC AIR STARTING VALVE ARE THE ONLY VALVES LOCATED ON THE CYLINDER HEADS

On 52 tests made on Type SI engines under actual plant operating conditions, the following fuel economies were obtained:

Half load, 0.47 lb.; three-quarter load, 0.427 lb.; full load, 0.426 lb.; 10 per cent overload, 0.435 lb.

On the test floor economy tests at full load averaged 0.39, 0.395 and 0.4 lb. per brake hp.-hr.

Lignite Burning Studied by South Dakota

IT IS customary for the residents of the state of South Dakota to consume each year 1,400,000 T. of coal hauled an average distance of 1000 mi. Increasing costs at the time and difficulties of transportation have contributed towards instigating an interest in the use of lignite found within a radius of 300 mi. from the center of population of that state.

These lignite deposits constitute by far the most extensive resource of fuel in the world, extending as they do through the western part of North Dakota, the eastern part of Montana and Wyoming, and the northwestern corner of South Dakota.

Adaptation of this inferior grade of fuel to the point where it can be accepted by the present consumers of high grade eastern coal is distinctly an engineering problem and one which is reported on in The Black Hills Engineer by Prof. Bancroft Gore of the Mining Experiment Station of the South Dakota School of Mines.

This report covers tests made at the experiment station and the outline of a simple commercial process which calls for upgrading crude lignite at the mines. It is proposed to crush the run-of-mine coal to nut size and pass it through revolving driers, following by screening to sizes suitable for domestic and steam purposes. Dust and buckwheat sizes would be removed and used in unit pulverizers or firing the driers and boilers at the coal mine. The use of the smaller sizes of dried coal is suggested for gas producers, steam plants equipped with automatic stokers, locomotives and in connection with low cost pulverizers adapted for grinding and blowing the lignite dust, either directly or indirectly, to the combustion chambers of stationary boilers, locomotives, cement and lime kilns and industrial furnaces. It is claimed that the upgrading process at the mine can be performed for a cost not to exceed 30 cents per ton of product.

Tests, using unit pulverizers, show very high combustion efficiency and high temperatures. The upgraded lignite has a fuel value equivalent to 80 per cent of that of the present quality of eastern coal entering South Dakota. Its cost in the consumers' bins is estimated at from a third to one-half that of imported coal and the potential supply is unlimited.

A Code of Ethics for Engineers

ENGINEERING work has become an increasingly important factor in the progress of civilization and in the welfare of the community. The engineering profession is held responsible for the planning, construction and operation of such work and is entitled to the position and authority which will enable it to discharge this responsibility and to render effective service to humanity.

That the dignity of their chosen profession may be maintained, it is the duty of all engineers to conduct themselves according to the principles of the following Code of Ethics:

1. The engineer will carry on his professional work in a spirit of fairness to employes and contractors, fidelity to clients and employers, loyalty to his country, and devotion to high ideals of courtesy and personal honor.

2. He will refrain from associating himself with, or allowing the use of his name by, an enterprise of questionable character.

3. He will advertise only in a dignified manner, being careful to avoid misleading statements.

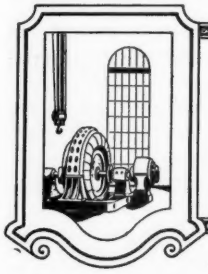
4. He will regard as confidential any information obtained by him as to the business affairs and technical methods or processes of a client or employer.

5. He will inform a client or employer of any business connections, interests or affiliations, which might influence his judgment or impair the disinterested quality of his services.

6. He will refrain from using any improper or questionable methods of soliciting professional work, and will decline to pay or to accept commissions for securing such work.

7. He will accept compensation, financial or otherwise, for a particular service, from one source only, except with the full knowledge and consent of all interested parties.

8. He will not use unfair means to win professional advancement or to injure the chances of another engineer to secure and hold employment.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Non-Inductive Alternating Current Circuits

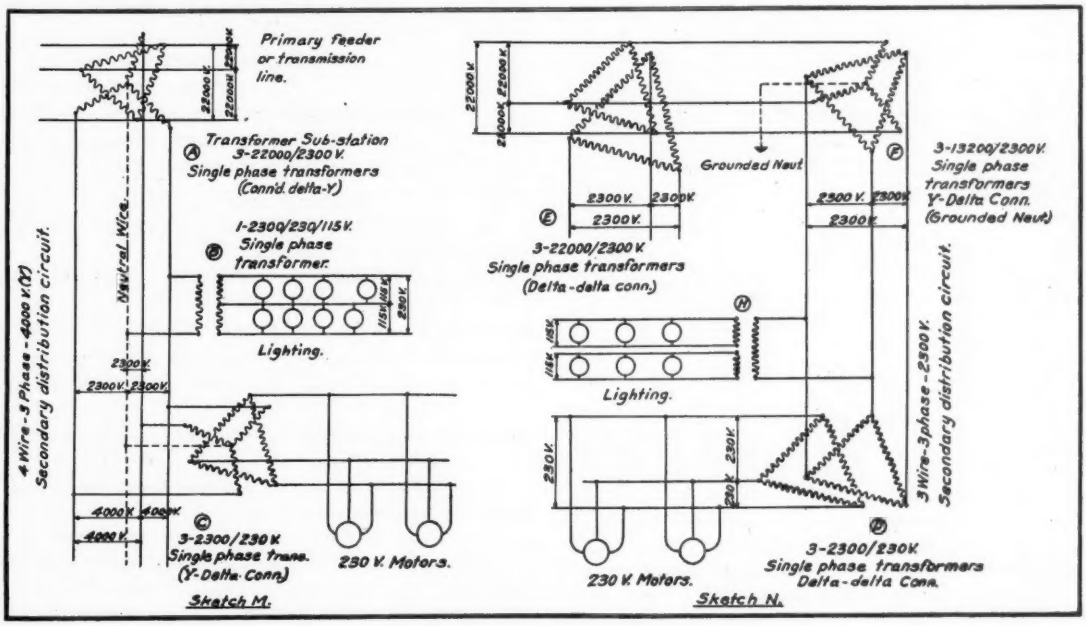
METHODS OF CALCULATING CIRCUITS IN WHICH THE INDUCTANCE AND CAPACITY EFFECTS ARE NEGLIGIBLE. BY E. K. McDOWELL*

ALTERNATING CURRENT transmission lines may be classified, broadly, according to two types—those in which the capacitive and inductive effects are of importance and those in which the effects of these properties may be neglected. The matter in this section applies, in general, to circuits of the latter type. Such circuits can be figured by approximate methods outlined under the following captions, which are similar to those used for d.c. circuits, with certain modifications to take account of effects of load power-factor. These methods can be (and are, generally) used for practical design of circuits of moderate capacities, low voltages and relatively short lengths; such as motor branch circuits and wiring of buildings for lighting, etc.

Inductive reactance and power-factor effects, referred to above, will, however, have to receive mention, of a preliminary and general character, in this article. This is necessary in order to define, as well as may be, the extent to which the non-inductive circuit methods referred to are applicable; and also in order to furnish a basis for making tentative allowance for load-power-factor effects.

GENERAL EFFECTS OF REACTANCE AND OF LOAD POWER-FACTOR

Electro-magnetic inductance is an effect associated with the continually-changing character of an alternating current flowing in any conductor, and with the magnetic field (due to the current-flow) which surrounds the conductor. Changes in the current cause corresponding changes in the magnetic field which, in turn, induce an e.m.f. in the conductor of such direction as to oppose the change in current. Associated with these effects is the mutual inductive effect of the two or more parallel conductors which constitute a circuit, resulting from the inductive effect upon one conductor of the magnetic field surrounding the other conductor or conductors. The aggregate effect of these conditions is to cause a counter-e.m.f. to be set up in the circuit, opposing the current-flow therein, which counter-e.m.f. is proportional to the frequency of the current, and is



TYPICAL 3 AND 4 WIRE DISTRIBUTION CIRCUITS

* Chief Engineer, Donora Steel Works, American Steel & Wire Co.

also a function of the diameter and spacing of the two or more conductors of the circuit. This counter-e.m.f. has the further general result of causing a drop in voltage somewhat similar to that caused by resistance; it thus constitutes an opposition to current-flow which (like resistance) can be expressed in ohms. When so expressed the opposition to current-flow due to these inductive effects is referred to either as inductive reactance, or simply as reactance; and is expressed quantitatively as ohms per unit length (usually per mile or per 1000 ft.) of one conductor.

Reactance effects can ordinarily be neglected in branch circuits such as those mentioned in the first paragraph of this article; when the circuit wires are all carried in the same conduit, or are separated less than, say, 1-in. centers.

When the circuit conductors are separated by more than a few inches the inductive reactance effect may increase the line voltage drop considerably; and the line reactance will also be large for aerial circuits where the wires are widely separated. Increase in spacing of conductors or decreased diameter thereof will increase the line reactance.

Load power-factor can be defined here, in a preliminary way, as the ratio (per cent) by which the kv.a. of the circuit must be multiplied in order to obtain the true power in kw. of effective energy supplied, by the circuit, to the motors or other connected load.

This reduction of the apparent energy supplied results from inductive reactance effects, similar to those already referred to, which take place to a greater or less degree in practically all electrical apparatus supplied with energy from a.c. circuits. The power-factor of different kinds of load varies considerably, depending on the type of equipment, load conditions, etc. Typical values are, say, 80 per cent for induction motors at full load, 95 per cent for incandescent lighting, and about 100 per cent for synchronous rotary converters and synchronous motors.

Ohm's Law is true, without qualification, for strictly non-inductive circuits and is true so far as the voltage drop due to resistance is concerned for all a.c. circuits, i.e., where I = effective current-amps, E_1 = effective resistance-volts, or e.m.f.-drop due to overcoming the resistance R (ohms); then

$$E_1 = IR \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Size of Conductor for Non-Inductive Circuits—Approx. Methods

In determining the size of conductor for non-inductive circuits, use is made of the d.c. equation described in previous articles for determining the size wire to give a certain allowable (or assumed) voltage drop. The line current is, however, determined by methods (outlined below) which take account of the load power-factor.

These methods can probably be applied, without material error, for the calculation of motor branch circuits and 115-v. lighting circuits, if of moderate capacities and lengths. Doubtful cases, i.e., those approaching the limitations previously outlined, should be investigated for line reactance-drop, by methods that will be outlined in subsequent articles of this series.

Quantities that are usually known, or that can be assumed, will be designated as follows:

p.f. = power-factor at receiving-end of circuit in per cent, i.e., load power-factor.

E_1 = allowable drop in voltage.
(can be assumed, tentatively, at 5 to 10 per cent of the nominal line voltage for motor circuits; or 1 to 2 v. for 110-v. lamps).

E = e.m.f. between conductors, at receiving end of circuit.

kw = total kilowatts of delivered power.

L = length (one way) of the circuit, in ft.

Single-Phase Circuits

For single-phase circuits the actual line-current I is first determined from the known quantities kw, E, and p.f. By definition of power-factor and kw:

$$P \text{ (in watts)} = IE \times \text{p.f.} \text{ or } kw = (IE \div 1000) \times \text{p.f.}$$
$$I = (1000 \times kw) \div (E \times \text{p.f.})$$

The value of E_1 that has been assumed as an allowable voltage-drop, together with the actual line current-amps, I, as just determined, is then substituted in equation (2) page 230, Feb. 15 issue, which is the same as for d.c. circuits:

$$\text{cir. mils} = 22\ I\ L \div E_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The nearest commercial gage or wire size having an area in cir. mils not less than that given by equation (2) will then be the size conductor that will give a voltage drop not exceeding E_1. This wire-size should also be checked for current-carrying capacity and for energy-loss, as noted under a later caption.

Two-Phase Circuits

For a 2-phase 4-wire circuit use the same procedure as just outlined, computing a single-phase circuit as for half the total power at the given voltage. Then the 2-phase transmission will require two such circuits.

Three-Phase Circuits

Let the known (or assumed) quantities be specifically designated as follows:

E = e.m.f. between any two-phase wires at receiving end of circuit.

kw = total kilowatts delivered power (receiving end).

L = one-way length of circuit, in ft.

p.f. = power-factor of load, or receiving-end power-factor.

E_1 = allowable voltage-drop between any two main conductors, or phase-wires.

(1) Determine the line current-amps per phase, I, from the following equation:

$$I = (580 \times \text{kw.}) \div (E \times \text{p.f.}) \quad \ldots\ldots\ldots (9)$$

This is a more convenient and easily-remembered form of equation (7) $I = \frac{P}{1.73\ E}$, as given on page 479 of the May 1 issue; and as such is of general use for determining the current-amps per phase in any 3-phase circuit when the given quantities are E, kw and p.f., which is generally the case.

Derivation of equation 9 is as follows: $P = 1.73\ E\ I$ (for any 3-phase circuit); as per equation (6) on p. 332 of article in Mar. 15th issue. Also, by definition of power-factor and kw:

$$kw = (1.73 \times I\ E) \div 1000.$$
$$\text{or} \quad kw = (I\ E \div 580) \times \text{p.f.}$$

and, solving for I,

$$I = (580 \times kw) \div (E \times \text{p.f.})$$

(2) Determine the size conductor that will give the allowable voltage-drop, by substituting E_1 and the value of I just determined, in the following equation:

$$\text{cir. mils} = (19\ \text{IL}) \div E_1 \quad \ldots\ldots\ldots\ldots\ldots (10)$$

This equation, derivation of which will be explained later, gives the size wire (in circular mils) required for each of the three main conductors, or phase-wires, of the circuit. As explained later, results are approximate, only, for circuits where the load power-factor is other than unity; but are theoretically correct for strictly non-inductive circuits of unity power-factor.

In general, equation 10 is probably sufficiently accurate for calculation of the usual 220-v. and 440-v. motor branch circuits of medium capacities; where the main conductors are laid in one conduit or are close-spaced, and where the circuit is only a few hundred feet in length.

For instance, this method might be applied for determining the conductor-size in such cases as the 230-v. (3-phase) motor branch circuits shown in the accompanying drawing, which appeared originally in the Mar. 15 issue, and is repeated (with certain corrections*) in the present article. This is providing that the three conductors for each circuit are laid in one conduit (or are otherwise close-spaced) and are, say, only a few hundred feet in length.

Derivation of Equation 10: This equation is a modified form of equation (2) in which account is taken of the phase-relations of the voltage-drops in the three main conductors. These relations were discussed on page 478, May 1st issue, in connection with the Equivalent-Y Method.

Let E_o = voltage-drop per phase, to neutral. Then, by equivalent Y method:

$$E_o = E_1 \div 1.73 \quad \ldots\ldots\ldots\ldots (a)$$

Equation (2) can be written—as for E_o—in the following form:

$$E_o = 11 \times I\,l \div \text{cir. mils} \quad \ldots\ldots (b)$$

where l is the total length of conductor of the circuit in which the voltage-drop E_o occurs. But, since E_o is the drop to neutral, the one-way length of line L, which is the total length of one conductor, is in this case the length which determines the voltage-drop.

Therefore l in equation (b) becomes L; and, substituting value of E_o from equation (a) we can write equation (b) as follows:

$$E_1 \div 1.73 = 11 \times I\,L \div \text{cir. mils}$$

or $$E_1 = (11 \times 1.73\ I\,L) \div (\text{cir. mils}) = 19\ I\,L \div \text{cir. mils}$$

which can then be written in the form

$$\text{cir. mils} = 19\ I\,L \div E_1 \quad \ldots\ldots\ldots\ldots\ldots (10)$$

The resistance drop in a given conductor, or voltage lost in overcoming line-resistance, can, of course, be readily calculated—in cases where the size of conductor is known—by the use of equations (2) and (10) written as solved for E_1; which, as before, denotes the voltage-drop due to overcoming line resistance. These equations then take the form of equations (11) and (12), shown below for convenience of reference:

For single-phase circuits:

$$E_1 = 22\ \text{IL} \div \text{cir. mils} \quad \ldots\ldots\ldots\ldots (11)$$

For 3-phase circuits:

$$E_1 = 19\ \text{IL} \div \text{cir. mils} \quad \ldots\ldots\ldots\ldots (12)$$

These equations are subject to the limitations previously stated, and give values of E_1 that are only approximately correct for circuits of other than unity power-factor.

Limitations of Approximate Methods

Limitations of these approximate methods for non-inductive circuits are that they are only approximately correct for circuits of other than unity power-factor. The voltage-drop, E_1, for a given size conductor would, in such cases, be greater than the actual voltage-drop as determined by the more exact Impedance Method (so-called), which has to do with Inductive circuits, i.e., those circuits where the effects of line reactance have to be considered. Consequently the conductor size, as determined by equations (2) and (10) would, in some cases where the load power-factor is less than unity, be somewhat larger than if determined by the Impedance Method just referred to. Results may therefore be considered as being on the safe side; provided that the line reactance is small and can be neglected without material error, as explained previously.

It should be understood that, strictly speaking, all a.c. circuits have some line reactance; and that, accordingly, any applications of the calculation methods outlined in this section involve a certain degree of approximation. In other words, the term "non-inductive circuit" used in this connection is somewhat misleading; since, properly speaking, there is no such thing as a wholly non-inductive circuit. What is really meant, in applying the term to the class of branch circuits, etc., referred to in this section, is that the inductive reactance (particularly the line reactance) of such circuits may be disregarded without material error; because it is relatively unimportant in effect on such circuits.

It is impossible to assign definite limits beyond which these so-called non-inductive circuit methods are inapplicable; but it has been attempted herein to give as definite an idea of these limitations as can be stated in general terms. The question as to what calculation methods should be employed in a given case is, in the last analysis, up to the individual judgment of whoever is responsible for the calculations. About the only sound basis for such judgment is experience gained by figuring doubtful cases of various sorts, employing the Impedance Method as well as these non-inductive circuit methods, and comparing the results.

Current-Carrying Capacity and Energy-Loss

Wire size determined by any of the preceding equations should also be checked for current-carrying capacity by the same methods as outlined in the Feb. 15 issue for d.c. circuits. Reference can be made, for this purpose, to the same table as there referred to. Equation (3) in the Feb. 15 issue should then be applied, and the energy-loss (power dissipated in overcoming line resistance) determined therefrom. The latter should, in general, be kept under 5 per cent for continuous-load current, but may be allowed to exceed this figure for intermittent loads and for the 25 per cent overload current usually provided for on motor branch circuits. This matter of allowable-energy loss will be referred to further in a later article.

---

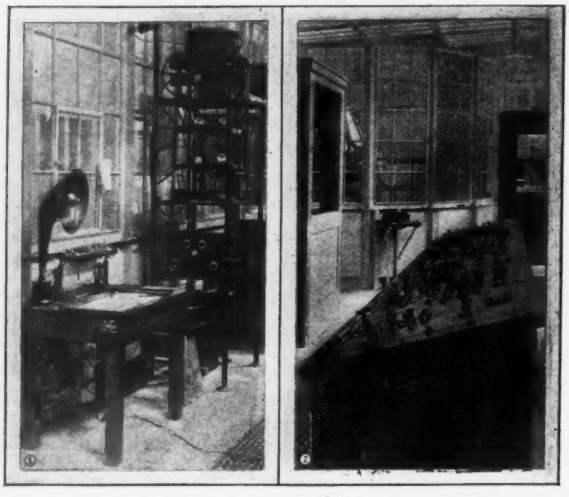
*It is desired to call attention to the transformer connections shown at points (C) and (E) on Fig. 1. Due to an error in reproducing this figure for printing, these connections were incorrectly shown thereon in our March 15 issue, where the figure originally appeared in the second article of this series. Fig. 1, corrected, is accordingly repeated in the present issue.

Also, immediately above Fig. 1 in the same article, the phrase "non-conducting" appeared (as a paragraph-caption). This should read "non-inductive." Also on page 323 of this March 15 article a certain line (9th of 3rd paragraph, first col.) reads "certain important voltage surges and disturbances." This portion should read "certain important advantages in the way of eliminating abnormal high-voltage surges and disturbances."

World's Longest Guided Radio Line on Pit River System

By Charles W. Geiger

WHAT IS SAID to be the longest guided radio telephone and telegraph system in the world has recently been put in operation by the Pacific Gas and Electric Co., between the Vaca-Dixon substation and Pit River Power House No. 1. The system utilizes the twin circuit 220,000-v. transmission lines between the two points for a conducting medium, a total distance of 202 mi., and is for the sole purpose of directing the operation



GUIDED RADIO USED ON PIT RIVER SYSTEM

A. Radio Equipment is located in this operating room just opposite bench board shown in B.

B. The bench board in Pit River Power Plant No. 1 is located close to the radio equipment which is arranged at the left along the glass partition of the operating room.

of the two stations both under normal and emergency conditions.

Coupling between the transmission lines and the radio equipment is obtained by means of a single wire antenna about 180 ft. in length. This wire is attached to the twin vertical circuit transmission towers at a point on the center line of the tower and at the elevation of the middle cross arm. Six standard 10 in. suspension insulator units are used for dead ending and supporting the antenna. The main station ground system is also used as a ground for the radio equipment. No counterpoise is used. The wave length used is betwen 9000 and 10,000 meters.

Transmitting equipment is the regular vacuum tube telephone transmission equipment similar to that used by the high powered broadcasting stations. Four 250-w. and one 50-w. Radiotrons are employed, two of which are used as oscillators and two as modulators with the 50-w. tube as a speech amplifier. The plates of the 250-w. tubes are supplied with a potential of 2000 v. d. c. from a 2-kw. generator. This generator has two commutators, each supplying 1,000 v. d. c. and a tap is taken off to supply 1000 v. d. c. potential to the plate of the 50-w. tube. Mounted on the same shaft with the 2000 v. generator is a 1⅜ kw., 125-v. exciter which also has sliprings for supplying 88-v., 30-cycle alternating current. This 88 v. alternating current is stepped down to 11 v. through a special 800-w. transformer and is used for lighting the filaments of the 250-w. and 50-w. tubes. The generator and exciter are driven by a direct connected 6¾ hp., 115-v. d. c. shunt wound motor. This motor derives its energy from the main station storage battery which is unusually large in order to handle the 220,000-v. oil circuit breakers. Normally the battery floats on the charging set and a contactor has been installed in connection with the automatic motor starter which short circuits a portion of the charging generator field rheostat and permits a rise in generator voltage to compensate for the extra load of the radio motor generator set. Thus under normal conditions of operation no drain placed on the storage battery. An automatic motor starter is used for control of the motor generator set, the starting and stopping of the set being accomplished by taking the telephone receiver off or putting it on the hook. The motor generator set and special 88/12-v. transformer were furnished by the General Electric Co.

Receiving equipment consists of a Colin B. Kennedy Corporation type 110 Universal Receiver which has been modified to make it a non-regenerative receiver, and a Western Electric loud speaking outfit using two stages of audio-frequency amplification.

Calling is accomplished by mounting a calling microphone in the horn of the loud speaker which, when the calling circuit is completed, will oscillate and howl in much the same manner that the ordinary telephone will howl when the receiver is placed against the transmitter. This gives a very loud note whose pitch will depend upon the natural period of oscillation of the diaphragms and which is clearly audible in all parts of the station. Ordinarily, it is not necessary to use the calling system, as the receivers are always in service and the operator near the set so that the loud speaker simply talks to him and he starts up his set and talks back. The system is arranged for simplex operation and all that is necessary is to operate a small telephone switch which energizes a contactor to connect either the transmitting or receiving set to the antenna, thus permitting talking or listening.

All the experimenting and development work necessary to place the equipment in a satisfactory operating condition was done under the direction and supervision of Dr. L. F. Fuller.

The accompanying photos show the temporary equipment during the experimental stage at Pit River Power Plant No. 1.

The first steel produced in the United States, according to the Geological Survey, Department of the Interior, was probably made in Connecticut in 1728, by Samuel Higley and Joseph Dewey. Crucible steel was first successfully produced in the United States in 1832 at the works of William and John H. Garrard, at Cincinnati, Ohio. Bessemer steel was first made in this country in September, 1864, by William F. Durfee, at an experimental plant at Wyandotte, Mich., and open-hearth steel in 1864 by the New Jersey Steel & Iron Co., at Trenton, N. J.

Latest official estimates of the United States Geological Survey places the world's petroleum production of 1922 at 851,000,000 bbl., showing an increase of 85,000,000 bbl. over 1921. The production in the United States was 551,000,000 bbl.

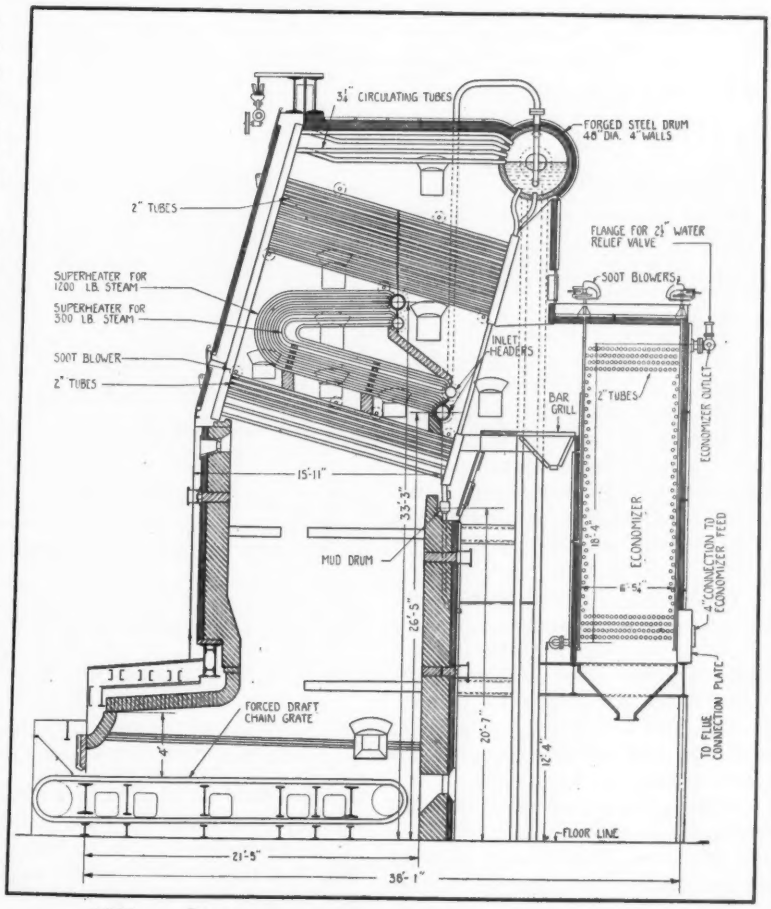
Design Features of New 1200-lb. Boilers

INCLINED HEADER, CROSS DRUM TYPE BOILER; FORGED STEEL DRUM WITH 4 IN. WALLS; TWO SUPERHEATERS USED, ONE OF WHICH REHEATS EXHAUST FROM HIGH PRESSURE TURBINE

WHILE tentative plans have been announced for several installations of 1200-lb. boilers and generating units the first detailed information on the design of the Babcock and Wilcox boilers for this pressure comes from the order placed by the Commonwealth Edison Co. of Chicago for installation at the Calumet station. This particular installation will take precedence as the first of its kind in this country.

Plans for the use of 1200 lb. steam are similar to those announced for the new Weymouth station of the Edison Electric Illuminating Co. of Boston which were presented on page 552 of the May 15 issue of Power Plant Engineering. Steam will be furnished at 1200 lb. pressure to an "extra-high pressure" turbine which will exhaust at about 300 lb. into a superheater supplying steam to the steam mains feeding the main station turbine. While the exact size of the 1200 lb. pressure turbo-generator has not been decided upon it is expected to be from 2500 to 3000 kw. The boiler will furnish about 110,000 lb. of steam per hour.

As shown in the accompanying sectional view, the unit is of the inclined header, cross drum type and comprises a Babcock and Wilcox forced draft chain grate stoker 24 ft. wide and 18 ft. 3 in. long, a lower deck of eight-high sections of 2-in. tubes having a setting height of 25 ft. 9¾ in., a primary and a secondary superheater in an interdeck space 8 ft. 1¼ in. between decks, an upper deck of seventeen-high sections of 2-in. tubes, two rows of horizontal 3¼-in. circulating tubes entering a 48-in. cross drum, and a Babcock and Wilcox steel contraflow economizer. The lower deck is not baffled; the upper deck has a vertical baffle causing the gases to make two passes. The complete unit is about 28 ft. wide, 36½ ft. deep, including the economizer, and 45 ft. high above the floor. The heating surfaces have not yet been definitely fixed, but they will be approximately as follows: Boiler, 15,750 sq. ft.; primary superheater, 2120 sq. ft.; secondary superheater, 3300 sq. ft.; economizer, 9230 sq. ft.



1200-LB. BOILER WHICH WILL BE INSTALLED BY COMMONWEALTH EDISON CO. OF CHICAGO, IN CALUMET STATION

Sectional headers of steel have a 1¼-in. front and back and ⅝-in. sides, and are designed to give the tubes a stagger of nearly 4 in. The eight tubes in each section of the lower deck are expanded into nine-high headers, the tube space not filled being that next to the bottom. The mud drum is 7¼ in. square, 1 in. thick and extends through each side of the setting, with a flange for blow-off valves at each end.

One marked point of difference in the construction of this boiler is in the cross drum. This drum is a forged steel cylinder, 48-in. diameter with 4-in. walls made up by rolling on a mandrel and swaging the ends.

Drum heads are integral, each with a manhole closed by a 12 by 16-in. manhole fitting. In order that the holes for connecting the circulating tubes to the drum may leave the largest practicable ligaments between circumferential rows of holes, an unusual arrangement of connections has been adopted. At the top of each uptake header two horizontal circulators are connected, but the circulators from each alternate header are bent downward and sidewise so that they are connected to the drum in the same circumferential row as the circulators without such bends. This makes the distance between these circumferential rows about 16 in. In the same way, the downtake nipples are not straight but bent so that the two downtake headers are connected to each of those circumferential rows of holes in the drum.

Connections to the drum comprise four 3-in. noz-

zles for safety valves, a 3-in. nozzle for the saturated steam connection to the lower header of the primary superheater, and two 3-in. nozzles for connections to a feed pipe extending the length of the drum below the water line.

For the primary superheater 8-in. headers are used which are drilled for three staggered rows of tube holes, with 72 tubes in each row. It is designed to raise the temperature of the steam under 1200 lb. pressure to 750 deg. F. The secondary superheater has 11¾-in. headers drilled for four staggered rows of 72 tubes each. This secondary superheater enclosed the primary superheater and is intended to raise the temperature of the exhaust from the extra-high-pressure turbine to 750 deg.

The economizer has 44 rows of tubes with twenty 2-in. tubes 20 ft. long in each row. It has not been decided whether the economizer will be operated at 1200 lb. pressure or at 300 lb. with a booster pump.

Improvements Reduce Waste

By H. A. Jahnke

FREQUENTLY we find that where an engineer has been in charge of one steam plant for many years, he has made very few changes in the plant and equipment for the purpose of reducing expense, etc. Some of these engineers, and often the plant owners, get into a rut or, in other words, they are satisfied as long as the wheels turn around and all goes well; hence many things go to waste that could otherwise be saved by installing up-to-date apparatus.

As an example, I shall relate the following. Some years ago, I took charge of a steam plant in a manufacturing concern. After being in charge for a few days, I noticed that much work was ahead of me if I wanted to cut out waste in the power plant as well as in the factory. This waste had been going on for years and had cost thousands of dollars in fuel and water wasted, all due to the fact that the former engineer had never given a thought to trying to improve things and reduce operating expense wherever possible.

At this plant, the office was located some distance from the power plant and factory; during cold weather the office was heated with live steam day and night and the condensation from the radiators and steam coils went to waste. As there was no night watchman in the plant, the boiler was filled with water at quitting time at night and a heavy banked fire left under the boiler. The next morning, it was always necessary to run cold water into it while much fuel was used to raise the steam up to the working pressure again. It was also necessary to be at the plant quite early each morning to be able to have the steam pressure up at starting time of the plant, hence the arrangement of the office heating system not only resulted in a great waste of steam and water but also wasted much of the engineer's time.

I decided to remedy this waste of steam, water and time by improving the office heating system, which was done by returning the condensate to the boiler day and night by means of traps. The improvements were made as soon as the heating system was not needed during the summer months.

In the old system, each radiator and steam coil in the office was equipped with an angle valve at the inlet and outlet as shown in Fig. 1. The valve at the outlet end was there for the purpose of preventing too much steam from escaping by nearly closing this valve, while the condensate was run into a catch basin, and then into the sewer.

I changed the system in the following way. All the angle valves at the outlet of each radiator and steam coil were replaced with a low pressure radiator trap. The outlets from these traps were connected into one main return pipe. As this return pipe could not be run overhead through the factory yard, due to the fact that there would not be sufficient pitch to the pipe to drain it thoroughly, it was necessary to run it in a trench from the office to the boiler room. This pipe was well

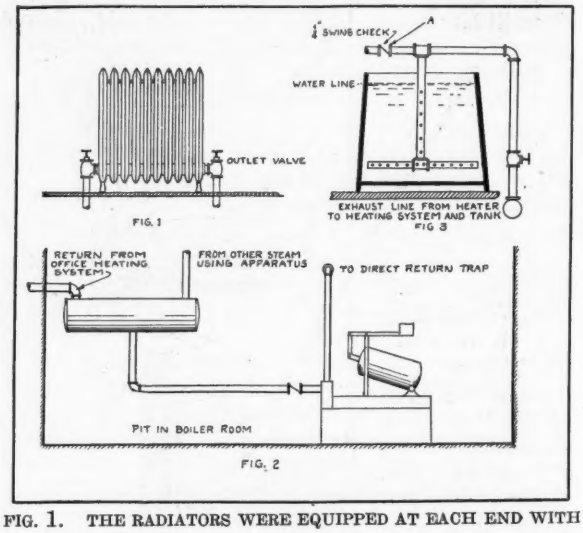


FIG. 1. THE RADIATORS WERE EQUIPPED AT EACH END WITH A VALVE

FIG. 2. A TILTING TRAP AND CONDENSATE RECEIVER WAS PLACED IN THE CONCRETE LINED PIT

FIG. 3. TO PREVENT WATER BEING DRAWN INTO THE ENGINE A ¼-IN. SWING CHECK VALVE WAS PLACED AT A

covered, then enclosed with a wood box which was covered up with earth after the job was completed.

In the boiler room in an out of way place, a pit was dug and lined with concrete walls and floor. Then a 1-in. lifting trap of the tilting type and a condensate receiver was installed in this pit (as shown in Fig. 2). Then the return pipe from the office was connected into this condensation receiver, as were also a number of other connections from other live steam using apparatus in the factory and power plant where the condensation had also been going to waste. A 1-in. direct return tilting trap was next installed on top of the boiler, to be used for boiler feeding as well as returning the condensate to the boiler. This condensate was first forced into the direct return trap by the lifting trap. When the heating system was placed in service again after the arrival of cold weather it was not necessary to run cold water into the boiler in the morning, with the result that it took much less fuel to bring the pressure up to the working point than it had taken formerly. A substantial saving of fuel, water, time resulted and there was less wear and tear on the boiler.

Exhaust Steam in Place of Live Steam to Heat Water

At this plant the factory was heated by the exhaust

steam from the engine, etc., after passing through a feed water heater.

Much hot water was used for manufacturing purposes in the factory during cold weather. This water was heated with live steam a number of times during the day shortly before they were ready to use the hot water in the factory. The water was heated nearly to the boiling point in a large tank. As this had to be done in a short time, it required a great deal of steam, and it was necessary to force the boiler considerably during this time.

Not all the exhaust steam was used for heating the factory, so I decided to make another saving in the fuel bill by using exhaust steam in place of live to heat the water in the tank. As there was no oil separator in the exhaust line of the engine, I installed one, then arranged the pipe system in such a way that part of the exhaust steam could be run directly into the tank while the engine was in operation. As a result of this change there always was a large supply of hot water ready to use at any time when needed in the factory, with no extra expense as formerly when live steam was used to heat this water.

At times a little cylinder oil would get by the oil separator and into the water tank; but for the purpose for which the hot water was used this oil was not injurious and the tank was cleaned about every four months, hence there was not much of an accumulation of oil during this time.

Figure 3 shows how the piping from the exhaust line to the tank was arranged. It will be noticed that holes were drilled into the vertical pipe and two cross pieces running horizontally. To prevent the engine from drawing water into the cylinder at any time from the tank, the horizontal pipe above the tank was equipped with a ¼-in. swing check valve as shown at A.

After making all these changes in the plant, a considerable saving in the coal resulted.

I believe there are many more plants in existence where waste of this kind is going on, but nobody in the plant seems to notice them until another man takes charge.

Then again we hear where these people complain of this high price of coal. The expense of fuel can be reduced considerably by the installation of the proper apparatus and making the necessary changes in the equipment, and above all a little thinking and perhaps a little extra labor on the part of the engineer, even though he has been in the plant for many years. It pays in the long run. Do not get into a rut and leave good enough alone; you are either the loser or gainer.

You may be looking for another position some day and by continuously trying to improve conditions in your plant you are also improving yourself, or, in other words, you will be more able to take hold of another plant at any time.

How the Leaks Were Stopped*

By W. F. Schaphorst

TROUBLE WAS experienced in an Eastern power plant by leakage of steam through joints A, B and C at the blowoff connections with a battery of Babcock & Wilcox boilers. The general arrangement is shown in Fig. 1. The leakage occurred in the lower side of the joint, due to the expansion of the pipe leading downward to the header. This pipe is shown in Fig. 1 and a number of them are shown in Fig. 2 leading from their various blowoff pipes. See pipes D, E, F, G, H and J.

Although these pipes are all curved as shown in Fig. 2, they still were stiff enough to force the joints A, B and C open. It was therefore decided to make some other provision for expansion.

This was ingeniously done without purchasing any more equipment aside from a few inexpensive compression springs and some longer bolts. The method of hanging the blowoff header is shown by K and L in Fig. 2. The hangers, it will be noted, drop from I-Beams and as originally designed they were not intended to "give" with expansion in the vertical pipes. Figure 3 shows another view of the hanger and loop.

Figure 4 shows how the straps were turned through 90 deg., how the attachment with the vertical rod was made and the longer bolts and compression springs were arranged.

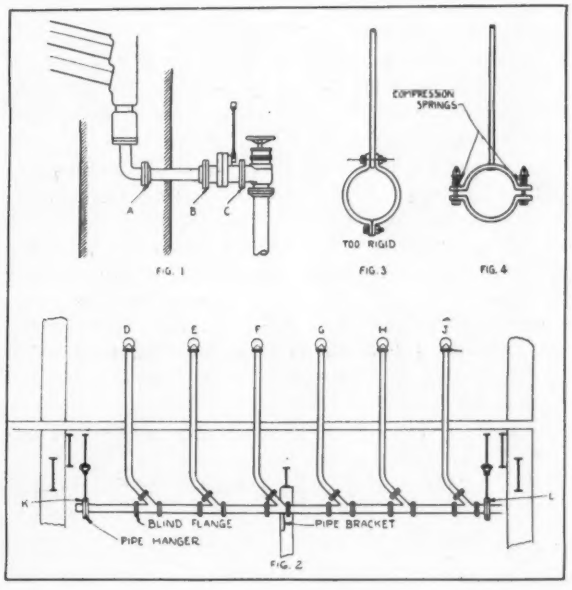


FIG. 1. DIAGRAM SHOWING WHERE LEAKS OCCURRED
FIG. 2. HEADERS CONNECTING WITH MAIN BLOWOFF LINE
FIG. 3. DETAIL OF HANGER
FIG. 4. SHOWING HOW STRAPS WERE TURNED AND HOW CONNECTION WAS MADE TO VERTICAL RODS

As a result, the leaks have all been stopped for good and instead of the tops of the vertical pipes being pushed upward, the bottoms of the pipes are now allowed to expand downward as temperatures increase. The small compression springs are then compressed, gaps form between the straps as indicated in Fig. 4 and that is "all there is to it."

This method is of especial interest because of the inexpensiveness of the alteration. It is quite possible that under similar circumstances some engineers would have insalled expansion joints or pipe bends in the vertical pipes to overcome the trouble. In this plant, however, the change was made without necessitating the cutting out of any boiler at any time.

*All rights reserved by author.

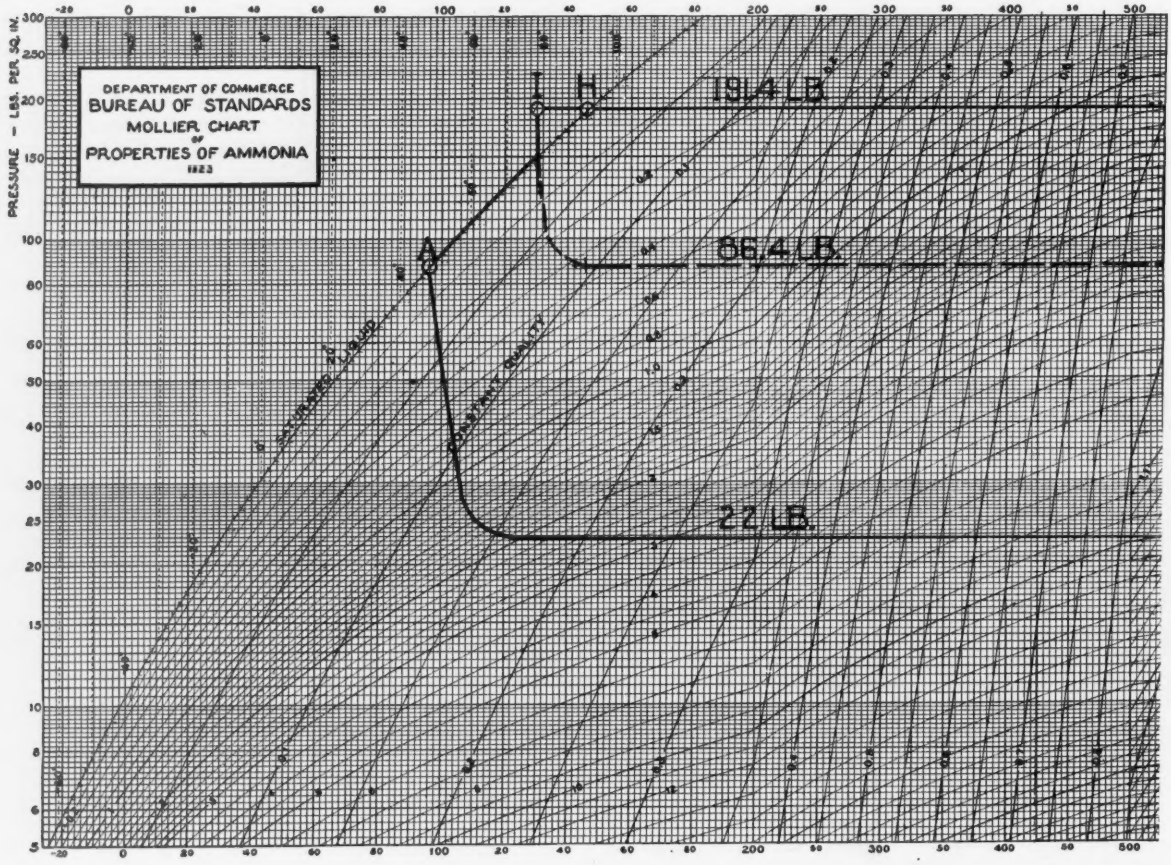
How to Use the Mollier Ammonia Chart

TEST DATA MAY BE RAPIDLY CHECKED BY USING NEW BUREAU OF STANDARDS CHART. BY JAMES R. RANDOLPH*

RECENTLY the Bureau of Standards completed a set of tables of the thermal properties of ammonia similar to the steam tables which have long been familiar to engineers. Several other ammonia tables had been prepared previous to these, but the data on which they were based was old and not as reliable as might be desired, so about 10 yr. ago it was decided to make an entire new set of tables based on new data observed with the utmost possible accuracy. This work was done by N. S. Osborne and his associates, Messrs. Mueller, Mayer, Cragoe, Stimpson and Dickenson, of the Bureau staff.

This task has now been completed and the tables published. It is believed that for 50 yr. at least they will meet all requirements of the engineering profession both for accuracy and range. The refrigerating industry has grown very rapidly in the last few decades, and it is likely that it will grow still more in the future; and as it grows, and as coal and other operating costs increase, it becomes more and more important that our fundamental data should be of unquestioned accuracy. Even if we make approximations in our calculations, it is desirable to know how much of an approximation we have made.

These tables are used in designing the plant in the first place and in checking its operation from time to time to see if there are any losses which can be prevented. It is this latter phase of their usefulness which will be discussed in this article.



In order to make it easier to follow the general method, the tables will not be used, but instead the Mollier chart which accompanies them. On this chart, the data are plotted in such a way that they can be easily read off without a great amount of computing. Only in work where observations have been made with the utmost precision, would it be necessary to use the tables instead of the chart; and for such calculations, preliminary work with the chart would show just what steps had to be taken. It serves thus as a map of the tables and as a guide to the more precise work which can be done with their aid.

HOW THE MOLLIER CHART IS LAID OUT

Use of the Mollier chart, or of the tables is based on three propositions. These are:

1. In any process which occurs at constant pressure the increase in heat content is equal to the heat added.

2. In adiabatic compression—compression at constant entropy—the thermal equivalent of the work done by

*Bureau of Standards.

the compressor is equal to the change in heat content of the fluid between inlet and outlet.

3. In a throttling process, such as occurs in an expansion valve, the increase in heat content is equal to the heat added. Where no heat is added the heat content is constant.

By the application of these three propositions, the various quantities of heat and work involved in any ideal compression refrigeration cycle can be calculated from either the tables or the chart.

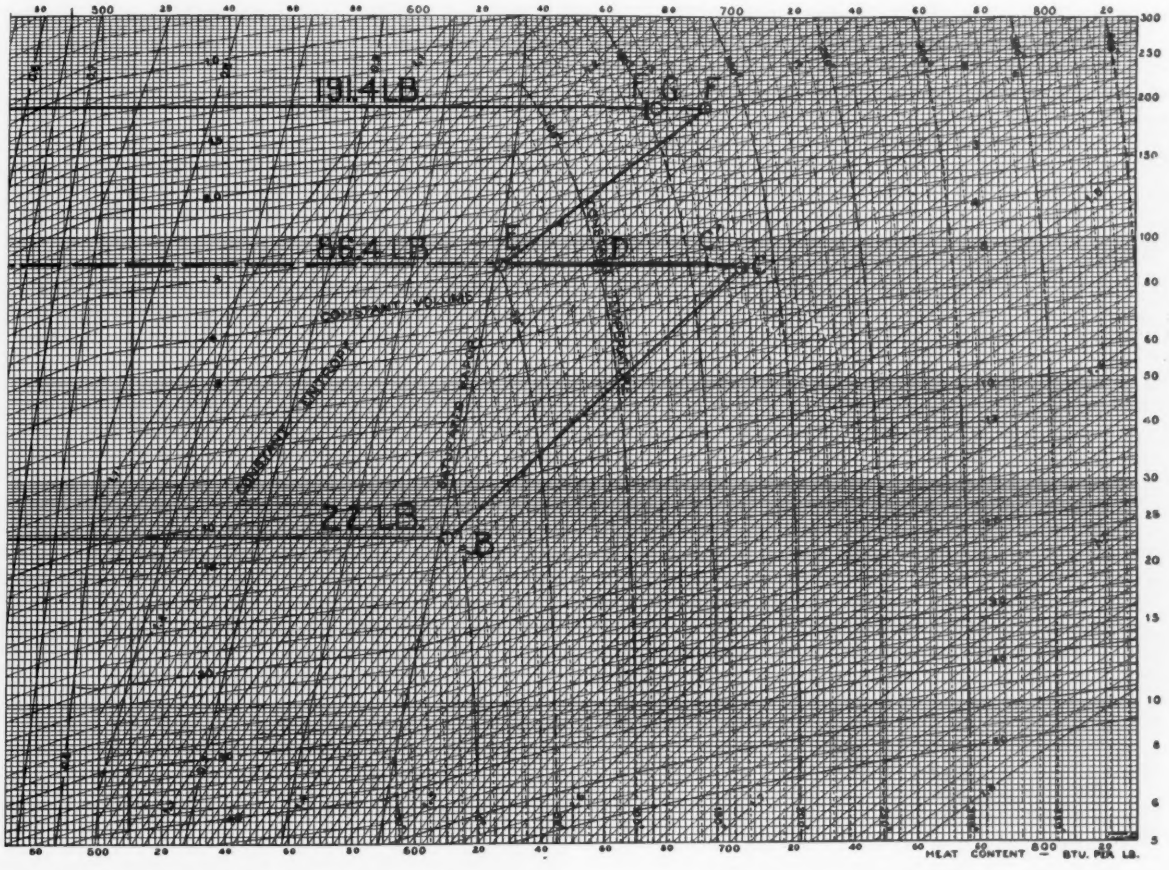
On the chart, it will be noticed that the ordinates are absolute pressures, the scale being spaced according to the logarithm of the pressure. The abscissas are total heat contents, starting from heat content at —40 deg. F. as zero, as this point is the same on both Fahrenheit and Centigrade scales. Vertical lines are therefore lines of constant heat content, while horizontal lines are lines of constant pressure.

Lines of constant temperature are shown dotted in the left and right ends of the chart, while between the curves of "saturated liquid" and "saturated vapor" they follow the corresponding lines of constant pressure, and are horizontal. On the "saturated liquid" line it will be noticed that the smaller subdivisions of the temperature scale have been indicated to permit a more accurate reading of the relation between boiling point and pressure.

Lines of constant volume can also be identified, as can lines of constant quality and lines of constant entropy, or adiabatics.

It will be noticed that between 200 and 500 B.t.u. the heat content scale has been greatly compressed. It is rarely necessary to locate any points in this region, and compressing the scale here makes it possible to use a more open scale at the ends of the chart without making the chart unduly long.

Laying out of the pressure scale proportional to the logarithm of the pressure also has the effect of permitting an open scale in the low pressure regions while condensing it in the regions of high pressure where fractions of a pound are less important.



Checking Test Data with the Chart

To illustrate the use of this chart for checking tests, data for an actual test will be used and the heat transfers in the various stages of the refrigeration cycle calculated from the chart. It will then be possible to compare these values of heat transfer with those calculated from other data and see how they compare. It will also be found that the chart can be used for the study of indicator cards. It makes possible the plotting of an ideal card for comparison and enables the operator to find many of the causes of low efficiency in operation.

Test data used is from a test described by George A. Horne in the A. S. R. E. Journal for January, 1922. Of the series of tests described, the particular one is for October 17. The machine on which these tests were performed is a compound compressor having a low-pressure cylinder of 22 in. diameter and a 13-in. high-pressure cylinder. Both have a 24-in. stroke. The speed is 150 r.p.m. and the rate at which ammonia is passed through

the plant is 109.44 lb. per minute and the estimated tonnage 280.8.

There are really two cycles to consider in this machine. The bulk of the ammonia (109.44 lb. per min.) passes through the entire process from condenser to brine cooler and then through both stages of the compressor. But there is also a small amount which is diverted from the outlet of the liquid cooler and evaporated at the intermediate pressure. This diverted ammonia cools the remaining liquid down to the boiling point corresponding to the intermediate pressure and also cools the gas between the stages of the compressor down nearly to the saturation point.

Therefore, the high pressure cylinder, condenser, and high pressure coolers are handling more ammonia than are the low pressure parts of the plant. Use of the chart will show us the reason for this and enable the calculation of the amount of this diverted ammonia. The diversion is accomplished by running the liquid ammonia into the intermediate receiver, where some of it boils. The liquid passes on to the brine cooler and the vapor goes to the high pressure cylinder.

This cycle will be treated as if it were two distinct cycles. It is as if there were two high-pressure cylinders, a large one and a small one, two condensers, etc., and coils of pipe in the intermediate receiver to effect the heat transfer without mixing the two batches of ammonia.

For both cycles the following data are given in the report of the test:

	Press. Lb. per sq. in. absolute
Discharge of high-pressure cylinder	191.4
Intermediate	86.4
Suction of low-pressure cylinder	22.0
	Temp. Deg. F.
Liquid ammonia from receiver	92.18
Liquid ammonia from liquid cooler	78.24
Liquid ammonia to brine cooler	48.1
Ammonia gas, low pressure suction	—9.3
Ammonia gas, low pressure discharge	181.2
Ammonia gas, intermediate cooler	99.7
Ammonia gas, high-pressure suction	50.8
Ammonia gas, high-pressure discharge	181.0
Ammonia gas, condenser inlet	156.5

Note that the gas is cooled by water from the low-pressure discharge temperature of 181.2 deg. to 99.7 deg., and from the high-pressure discharge at 181 deg. to 156.5 deg. The liquid is also cooled by water to 78.24 deg.

Using these data points can be located on the chart which show the conditions at the important points in the cycle. These are shown in the heavy lines drawn on the chart. From the chart it is then a very simple process to measure the change in heat content corresponding to any part of the cycle. In the following table these values are given for the main cycle, while some of the corresponding values calculated from the other data of the test are given for comparison. For example, the value of "heat taken from brine" is obtained from the quantity of brine, its specific heat, and the change in temperature it undergoes.

		From chart	Calculated in test
A-B	Heat taken from brine per lb. ammonia	514 B.t.u.	519
B-C	Heat equiv. of work in low pressure cyl.	94 B.t.u.	
E-F	Heat equiv. of work in high pressure cyl.	66 B.t.u.	
A-F	Total heat input	674	
C-D	Heat to water intercooler	47	52.4
D-E	Heat to ammonia intercooler	31	
F-G	Heat to gas cooler	15	
G-H	Heat to condenser	531	533
H-I	Heat to liquid cooler	16	18.7
I-A	Heat to diverted ammonia	34	
	Total heat removed	674	

The amount of ammonia evaporated in the intermediate receiver and diverted from the low pressure parts of the cycle can now be calculated.

D-E	Heat to diverted ammonia from gas	31
I-A	Heat to diverted ammonia from liquid	34
	Total	65
I-A	Heat content of diverted ammonia	496

Ammonia diverted per lb. of ammonia $65 \div 496 =$ 0.131 lb. circulated through brine cooler.

It is now possible to compare the work done in compressing a pound of ammonia as derived from the chart with that obtained from calculations of the indicated horsepower. To do this add together the heat equivalent of the work per lb. in the low-pressure cylinder and 1.131 times the heat equivalent of the work in the high-pressure cylinder. This gives

B-C	Heat equiv. of low pressure work	94
	1.131 × (E-F) heat equiv. of high pressure work	75
	Total	169

This agrees fairly well with the value of 172.3 calculated from the indicator cards, and it is probable that the difference is due in part to the pressure drops in the valves which the indicator cards include.

It is also possible to calculate the heat equivalent of the work that would be required if there was adiabatic compression in both cylinders. To do this, follow up the adiabatics from B to C′ and from E to F′. The values of work per pound now are:

B-C′	Heat equivalent of L. P. work (adiabatic)	82
E-F′	Heat equivalent of H. P. work (adiabatic)	47
	0.131 × (E-F′)	6.3
		136.3

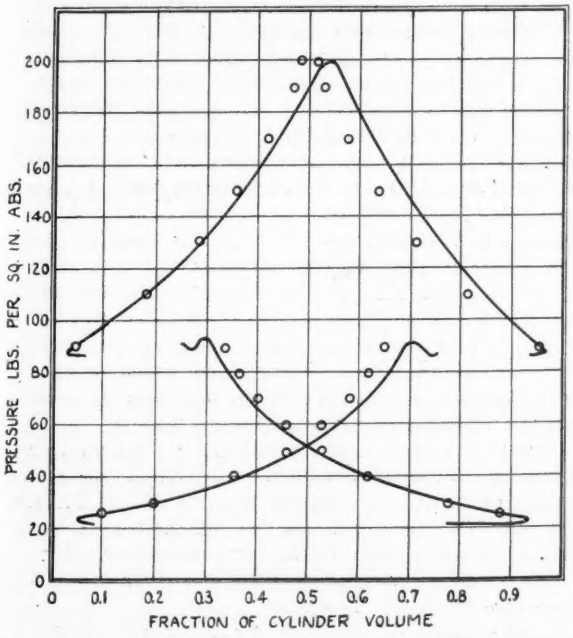
There is therefore a loss in the compressors of 33.7 B.t.u. per lb. of ammonia, or 20 per cent of the indicated work.

Interpretation of Indicator Diagrams

In order to find the cause of this loss, it will be necessary to construct ideal indicator diagrams and compare

them with the actual ones. This comparison is shown in the illustration, where the circles represent points on the ideal diagram as taken from the chart, while the full lines show the actual diagrams.

To get the points on the low-pressure diagram, take point B on the chart first. Here the pressure is 22 lb. per sq. in., and the chart gives the volume of a pound of the gas as 12.6 cu. ft. Follow up the adiabatic, or line of constant entropy, through this point, choose several other points along it, and record their pressures and volumes. It is then necessary to reduce the volumes to the scale of the indicator diagram by multiplying them by such a factor that the volume at B is equal to



CIRCLES REPRESENT POINTS ON IDEAL INDICATOR CARDS AS TAKEN FROM CHART

the volume at the toe of the diagram. The ideal high pressure card is obtained in similar fashion.

It will be noticed that on all the cards except that for the crank end of the high-pressure cylinder the actual curve falls below the ideal, whereas on that card it falls above.

Now, if the condition shown on the three cards were due to a loss of heat from the cylinders, there should be a reduction in the work of compression, not an increase. As the cylinders are for the most part well above room temperature there cannot be enough addition of heat to account for the H. P. crank end card.

It would seem that all of this loss in power is due to leakage past the valves and pistons. In the H. P. crank end there is a leak past the discharge valve; in the other three there is leakage past the suction valves; and in all there is probably some leakage past the pistons. As this leakage is causing a loss of 20 per cent of the power supplied to the cylinders, it is obviously well worth remedying.

The following is a list of possible faults in operation which can be shown by analysis of the indicator card such as have just been discussed, together with their symptoms.

1. Leaky discharge valves. Actual curve too high. Loss of power.

2. Leaky suction valves and pistons. Actual curve too low. Loss of power.

Heat leak out of cylinder. Actual curve too low. Gain in power.

4. Heat leak into cylinder. Actual curve too high. Outside temp.

Besides these losses, the indicator card also shows a loss in energy due to friction in the valves. In this case, it is found that the average drops in pressure through the valves are 2 lb. for the L. P. suction, 7 lb. for the L. P. discharge, 5.5 lb. for the H. P. suction, and 9 lb. for the H. P. discharge. These pressure drops result in an extra amount of work being done by the compressor equal to 1.7 B.t.u. per lb.

Does the Ammonia Intercooler Pay?

It would also be possible to use the chart for answering questions as to the design of the plant, as for instance, in finding out whether the use of ammonia for intercooling the vapor and cooling the remaining liquid as described, is profitable from an operating point of view. This is done by plotting the cycle as it would be with the ammonia intercooler left out. It will then be found that the work in the compressor per pound of ammonia is thereby decreased from 169 B.t.u. to about 166, whereas the amount of heat removed from the brine per pound is decreased from 514 to 480.

Thus for the ammonia going through the full cycle 514 B.t.u. are removed for an expenditure of 169 in the compressor, a ratio of 3.04. Of this, the small amount of ammonia diverted takes 3 B.t.u. in the compressor and removes 34. It is therefore about three times as efficient in converting work into cold as is the ammonia which goes through the whole cycle.

It also serves to reduce somewhat the average temperature in the brine coils and hence permits them to be made smaller and it reduces the size of the compressor, especially of the low-pressure cylinder.

Cranes Facilitate Ice Harvesting

Cranes used in harvesting ice in the modern ice plant are a marvelous improvement over some of the earlier types and can be considered the most important piece of harvesting equipment. The day when the tank man was expected not only to pull the ice, but then also pull the crane has long since passed, especially in the modern electric plant.

Some plants use an air or electric hoist on the crane by which the heavy load is lifted and carried, but the trolley is pushed across the tank by hand and the crane pushed lengthwise of the tank room by hand. Some others have an electric hoist motor with hand-operated trolley and electric traveling motor. These are commonly called two-motor cranes and are a step in advance of the one-motor crane. The modern electric plant, however, uses a three-motor crane for the hoist, trolley and crane travel, thus doing mechanically in a quicker, easier manner the heavy work of handling the loads which is so laborious and fatiguing in cases where cranes are partially or wholly hand-operated. The fatigue on the tank men naturally is not conducive to fast, regular pulling and is detrimental to the management of the plant as indicated by the labor turnover.

LETTERS DIRECT FROM THE PLANT

Boiler Furnace Design

WITH THE publication of the paper, "Boiler Furnace Design," in Power Plant Engineering, May 1, the results of investigations by Mr. Ricketts have been made available for all engineers interested in this subject.

In view of the wide distribution of Mr. Ricketts' paper, the following comments are made to discuss and interpret the facts in that part of the paper which

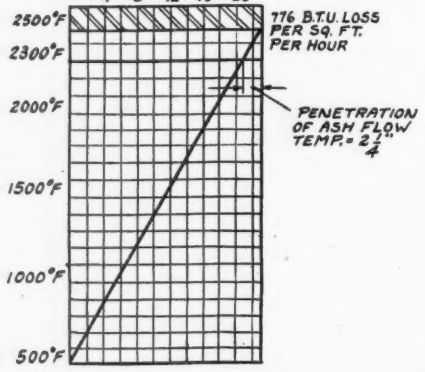


FIG. 1. TEMPERATURE GRADIENT THROUGH AN UNINSULATED FURNACE WALL

deals with wall construction. Much has been said and written about ideal wall construction, but it is difficult today to make a general statement which will cover this subject completely. The ideal wall is one which will give greatest economy when viewed from the standpoints of: (1) Low heat loss due to radiation, (2) low cost of construction, and (3) long refractory lining life.

Your attention is invited to Fig. 5 of Mr. Ricketts' paper. The importance of proper wall insulation to boiler economy is clearly shown. The heat loss through the wall which is composed of 9 in. of fire brick, 4½ in. of insulating brick and 8½ in. of red brick with a furnace temperature of 2500 deg. F. is 310 B.t.u. per sq. ft. per hour—the total thickness of this wall is 22 in. With the wall composed of 13½ in. of fire brick and 9 in. of red brick, the heat loss with a furnace temperature of 2500 deg. F. is 776 B.t.u. per sq. ft. per hr.—this is with a wall thickness of 22½ in. The saving due to insulation is then 776 — 310 = 466 B.t.u. per sq. ft. of boiler wall per hour.

In order to bring these savings down to dollars and cents, a boiler with furnace dimensions has been assumed and the return on the investment in insulation is computed below:

Assume boiler furnace 24 ft. wide, 20 ft. high and 14 ft. long. The total area through which heat radiates —side walls and front equals:

$$14 \times 20 \times 2 + 24 \times 20 = 1040 \text{ sq. ft.}$$

Assume further that the boiler in the case operates 300 days per year, 24 hr. per day on coal having a heat content of 13,500 B.t.u. per lb.; coal valued at $6 per ton of 2000 lb. on the grate, with a boiler efficiency of 75 per cent, the saving in B.t.u. per year equals:

$$24 \times 300 \times 1040 \times 466 = 3{,}489{,}408{,}000 = \text{B.t.u.}$$

saved per year.

Savings in Tons of Coal:

$$\frac{3{,}489{,}408{,}000}{0.75 \times 13{,}500 \times 2000} = 178.94 \text{ T.}$$

Dollars Saved per Year by Insulation:

$$178.94 \times \$6.00 = \$1073.64$$

In order to insulate one square foot of surface 4½ in. thick 6.5 insulating brick would be required. The best insulating brick are 9 × 4½ × 2½ in., standard fire brick size. A certain number of red brick will be displaced by the insulating brick—the red brick are usually about 8 × 4 × 2 in., and 8.5 brick will be displaced per sq. ft. by the use of insulation.

1404 × 6.5 = 6750 insulating brick (9 × 4½ × 2½ in.)
1040 × 8.5 = 8850 red brick (8 × 4 × 2 in.) displaced by insulating brick.

Figuring the cost of insulating brick at $100 per M on the ground, the gross investment in insulation is:

$$6750 \times \$100 = \$675.$$

From the gross investment should be taken the value of the same number of red brick displaced together with the value of the additional red brick displaced, and the labor which would be required to lay the additional red brick.

6750 red brick at $20 per M with mortar =	$135.00	
2100 red brick at $45 per M with mortar and labor =	94.50	$229.50
Net Investment in Insulation		$445.50

The return on the net investment in insulation is then:

$$\frac{\$1073.64}{\$445.50} \times 100 \text{ per cent} = 241 \text{ per cent.}$$

This shows that insulation of a boiler furnace is justified from a fuel conservation standpoint alone. As a matter of fact, complete insulation of a boiler setting between the fire brick and the red brick, or between the fire brick and the steel casing, is justified and is very common practice. The insulation of boiler tops with insulating brick is also widely practiced. The invest-

ment in insulation is returned within the first five months based on the figures in Mr. Ricketts' paper.

Penetration of dangerous temperatures in large boilers operating at high capacities is almost wholly chargeable to regulation of pressure and draft, other factors being equal. Mr. Ricketts' paper in "Power Plant Engineering," page 468, paragraph 4, shows that with a furnace temperature of 2440 deg. F. and slight draft in the furnace, the wall temperature was 2030 deg. F.; with 0.05 pressure the wall temperature was 2300 deg. F.; with one inch pressure the wall temperature rose to 2380 deg. F. With a good grade of fire brick and a slight draft over the fire, it may be assumed that little or no erosion of fire brick by molten ash occurs. The investigation by Mr. Ricketts and his associates also shows that little difficulty need be expected from straight fusion of the fire brick.

Figure 2 included in this comment shows the relationship between the use of insulation and the penetration of dangerous temperatures. This is somewhat different from the relationship shown in Mr. Ricketts' Fig. 5 assuming the same conditions shown in Fig. 5 and the last paragraph on page 469 of Power Plant Engineering.

Figure 1 shows the temperature gradient through a wall composed of 13½ in. of fire brick and 9 in. of red brick as used by Mr. Ricketts. As a matter of fact, the temperature gradient from fire brick and red brick is not a straight line, but it may be considered so when used in connection with this discussion. The penetration of ash flow temperatures is shown to be in this case in Fig. 1 to be about 2¼ in.

Figure 2 shows one o fthe walls in Mr. Ricketts' Fig. 5. This wall is composed of 9 in. of fire brick, 4½ in. of insulating brick and 8½ in. of red brick. The temperature gradient through the insulated wall is shown in solid line Fig. 2. The dotted line is temperature gradient through fire brick and red brick Fig. 1, which has been superimposed to facilitate comparison of temperature gradients of Figs. 1 and 2. This shows plainly that there is an increase in temperature on the back of the fire brick of only 150 deg. F. due to insulation. It should always be remembered that the use of insulation does not affect conditions of draft or pressure within the furnace nor the temperature of the inner face of the fire brick. The penetration of ash flow temperatures in the insulated walls is about 2⅜ in. This is practically the same as that shown for the solid fire brick and red brick construction.

The question of penetration of dangerous temperatures or the penetration of ash flow temperatures is based almost entirely on theory, according to the writer's understanding of Mr. Ricketts' article. The only actual tests conducted on temperatures are those shown in Fig. 2 of Mr. Ricketts' article.

Insulating brick can be practically and easily installed between the fire brick and the red brick in brick set boilers, or between the fire brick and steel casing in steel encased boilers. The proper thickness of refractory lining should always be allowed as a protection for the insulating brick. With the insulated wall construction shown above, namely: 9 in. of fire brick and 4½ in. of insulating brick and 8 in. of red brick in a boiler operating at high capacities, it would be highly desirable to use an insulating brick which would withstand a temperature of 2000 to 2100 deg. F. without change in character or size. This is a very important point.

Questionnaires sent recently to large public utility plants in which insulation has been used for some time revealed the fact that no difficulties had been experienced with the refractory lining due to insulation.

In Mr. Ricketts' paper, he brings out the difficulties encountered when fireclay is used to lay up refractory lining in boilers operating at high capacities. By using a good grade of high temperature cement, the danger of penetration of molten ash can be considerably reduced. The use of high temperature cement merits consideration of every boiler engineer.

When a pulverized coal or forced draft stoker flame strikes the furnace wall, the effect of ash erosion is most pronounced. These flames carry small particles of molten ash which penetrate any cracks or pores in the

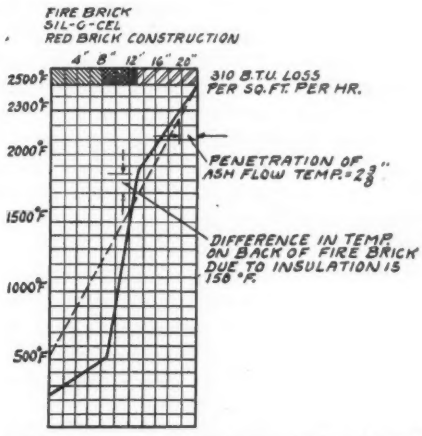


FIG. 2. TEMPERATURE GRADIENT THROUGH AN INSULATED FURNACE WALL

brick work. A good grade of high temperature cement forms a definite bond between the fire brick and eliminates any danger of cracks which would allow the molten ash to get into the brick work.

Based on the foregoing information, the logical conclusion is that the ideal boiler wall is an insulated one regardless of whether the boiler is brick set or steel encased.

C. A. FRANKENHOFF.

East Orange, N. J.

Oil Grooves on the Journal

IN THE May 1 issue, page 491, is an article by E. J. Jordan on "Scraping a Babbited Bearing"—a good article, which shows a fine trait of resourcefulness that is valuable to every engineer. I am pleased to note, I believe, the second man who will agree with me in a radical change in the treatment of journal bearings, i.e., to groove the journal instead of the bearing. Engine builders and operators have, for generations, cut numerous and fantastic oil grooves in the shells of babbited bearings with no thought of any other way, just because father and grandfather always did it thus; no other method could exist, and because of this it would be heresy to use any other method.

Grooves in the bearing will soon wear out unless unusually large, will fill with dust, and will require

renewing occasionally. On a heavy bearing, oil will not enter freely between two close fitting surfaces (as note a plug cock, for example) and needs a generous pressure to assist its entry as required. When this is afforded, there will have been a real reduction of the bearing surface, from 10 to 15 per cent or more, and when the bearing is designed with a certain diameter and length of journal to carry an average load any reduction of bearing surface must be considered seriously.

Assume a journal 10 in. in diameter and 20 in. long having a projected area of 200 sq. in. with 200 lb. pressure per sq. in. as usually designed.

It can be understood that the quarter boxes carry none of the load, and their curve would reduce the bearing area some 20 sq. in. Then the grooving reduction of some 20 sq. in. additional would leave an actual bearing surface of 160 sq. in., thus making the real load 250 lb. per sq. in. of bearing susrface.

By leaving out the grooving, we would have 180 sq. in. and load of 222 lb. per sq. in. (as above designed). The circumference of the journal is 31.4 in. and of this 9 in. is lying on the bearing, thus showing that there is about 22 in. of shaft surface that has no weight at all on it. In other words, the bearing is under a rubbing friction all the time, and the journal surface is under friction one-third of the time; therefore it can well spare the necessary surface to cut most generous oil grooves along the whole of its length.

These grooves should be all of 5/16 in. wide and ⅛ in. deep and, say, four of them. If need be, they can readily be cleaned without raising the shaft. They will catch a generous flood of oil while on top and carry it right around to where needed, practically a rotary pump putting the oil where it is needed.

I grooved a shaft once on an old engine that had all-brass shells, flanged in so that the shaft would have to be raised about a foot. A steel I-beam cleared the flywheel just one inch so it could not be raised. The quarter box oil grooves were all worn out so I concluded that the bottom shell was in the same condition. On a Sunday I cut three grooves in the journal, and all was well.

Another case I saw was in the shop of a leading builder of Corliss engines. Four grooves ½ in. wide and ¼ in. deep were cut in the journal and I was told that the purchaser had demanded them so, but everybody was aghast at the idea.

Cincinnati, Ohio. W. V. WHITE.

Phasing Out Alternators

IN READING the article on phasing out alternators in the April 15 issue, I was reminded of an experience which I had at one time which was similar and in that instance, the motors ran in the right direction when getting current from either machine; but when both of the switches feeding the motors were put in, there was difficulty at once.

We had two generators as shown in the accompanying sketch, which were connected to run in parallel by the main switches as shown. These machines were in one power house and there were two other plants within the factory grounds some distance away; it was customary to run generators 1 and 2 in parallel with them at times. The switches feeding to the outside plants are not shown on the main switchboard. The two generators were driven by oil engines and for auxiliaries there were two high pressure air compressors, a cooling water pump and a motor-driven exciter set. To supply the auxiliaries with current, a special bus was made up on a separate switchboard which is shown on the sketch. The lines connected to the switches A and B were from the feeders connecting this plant with the two outside plants. This arrangement was made in order that current might be obtained to start the auxiliaries when the main generators were shut down.

It will be seen that a connection is made from the leads to each generator inside of the main switch to the auxiliary switchboard. When the two machines were running one of these switches leading from them was closed and the power for the auxiliaries was supplied from that source. The reason for this was to separate the power required for operating the auxiliary motors

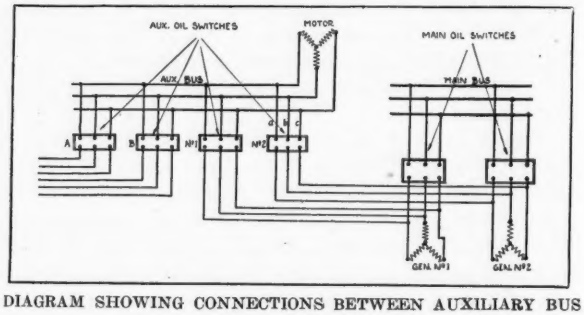


DIAGRAM SHOWING CONNECTIONS BETWEEN AUXILIARY BUS AND GENERATORS

from the amount passing through the wattmeter which would only record the net output of the machine. The separate switchboard for handling this current was an idea of the superintendent of the power department.

When this new board was ready to operate, the motors were all tried out and connected to run in the same direction with each switch in at a time; however, it was necessary to have any two of the auxiliary switches in at the same time and when this was done, the machines or the outside plants would be tied together in the same way, as they were connected by the main switches and to disconnect them, both main and auxiliary switches must be opened.

When the plant was to be started up in the morning, all switches on both boards were open and usually one of the other power plants would have a water wheel driven generator on the line so that power would be available to start the exciter, the circulating water pump or the air compressor. So if the switch A should be closed, No. 1 generator would be started up, synchronized, and thrown on the line and then No. 2 in the same way. The thing to do now was to change the auxiliary switches so that the motors would be supplied with power from the generators inside of the main wattmeters. To accomplish this, either No. 1 auxiliary switch or No. 2 would be closed and then the switch A would be opened. It was important not to open this switch until some other was closed since all of the motors would have stopped.

This being the arrangement desired, it was necessary to see if it would work out all right and since the motors all ran correctly when supplied from any separate

switch, it was now necessary to have both machines in parallel on the main bus bars and the feeder switches to the other plants closed. Then with one auxiliary switch closed, to close all of the others and see what would happen.

Such an experiment should always be made at a time when power is not required to operate the factory, but the electrical force felt certain that there would be no difficulty so the arrangement was tried out with the result that, after three of the auxiliary switches were closed without mishap, when the fourth which was connected to No. 2 generator was closed, there was a display of fireworks and fuses blew in all of the plants, which shut down everything for a short time.

This result puzzled the electricians until it was suggested that the wires from No. 2 auxiliary switch might be connected to the auxiliary bus bars in such a way that the motors would run in the right direction and yet when this switch was closed with the others, a connection would be made that would cause a short circuit through the two sets of bus bars. The leads from switch No. 2 were changed and the experiment was tried again with excellent results.

This arrangement is not to be recommended unless an interlocking device is provided in order to prevent an auxiliary switch from a dead machine being closed for it is quite possible that when something happens to cause any confusion in the plant, operators are liable to forget what they should do and throw the wrong switch. A separate wattmeter for auxiliary power would answer the purpose very well.

East Dedham, Mass. GEORGE H. KIMBALL.

Centrifugal Tension in Belting

THE TWO photographs submitted by William D. Young and shown on page 495 of the May 1 number of Power Plant Engineering interest me greatly, particularly his Fig. 2, which shows an over pull drive. This top pull drive is different from most top pulls in that the lower belt shows a reverse curve; that is, the belt does not fly away from the driving pulley as it is supposed to do in accordance with orthodox teachings.

I have an explanation to offer for this reverse curve, and that is,—the intimate contact that is probably achieved between the belt and the pulleys. When contact is so perfect that all air is excluded, the natural tendency is for objects to stick together.

When a pulley and belt fit so perfectly that air is excluded, it is quite probable that there is a similar tendency to stay together, hence the reverse curve—which is an ideal condition.

Newark, N. J. W. F. SCHAPHORST.

Stop Valve at Boiler Outlet Is Unnecessary

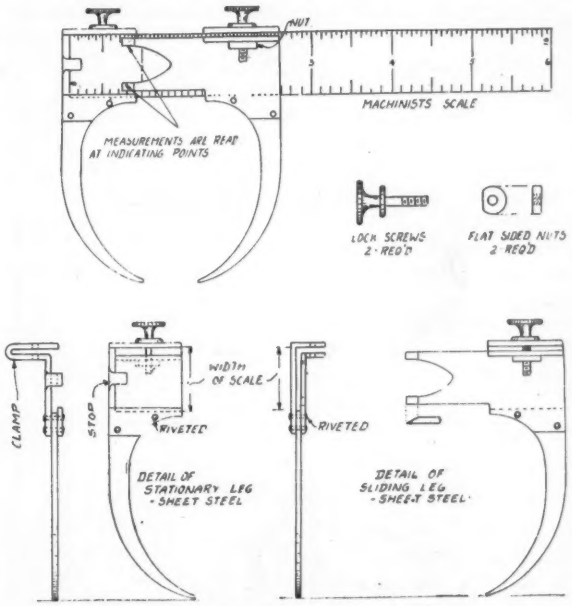
IN THE issue of May 15, on page 540, I notice an article by L. H. Floyd on the installation and operation of non-return valves, with which I agree fully, when a non-return valve is installed and the construction is such that the internal working parts cannot be mechanically moved from the outside of the valve; however, it is not necessary to employ valves of this design, since there are other types on the market.

It is true that most non-return valves consist of a dashpotted check with a pin stop connected to the handwheel so that the check may be forced down on the seat. On the Edward non-return valve, for instance, the dashpot piston is positively connected to the stem and handwheel and the pin stop is on the bottom of this piston, so that if at any time there is any slight sticking of this piston when the check is down on the seat, the stem can be screwed up or down, thus moving, wiping, and freeing the internal working parts of this valve. With a valve of this type there will be no occasion for using the stop valve at the boiler outlet and thus increasing the frictional resistance in the header line.

Pittsburgh, Pa. B. M. HERR.

Direct Reading Scale Caliper Attachment

THE SPARE time of a mechanic is profitably expended in the construction of some special tools, the caliper being among the most popular types of tools which are



CONSTRUCTION OF DIRECT READING SCALE CALIPER ATTACHMENT

shop made, and the serviceability of the caliper is a recognized feature.

A caliper construction which is worth considering, is a design for use in conjunction with any machinist's scale, and the calipered dimension is read direct, without transferring this from the work to the scale, as in the usual method.

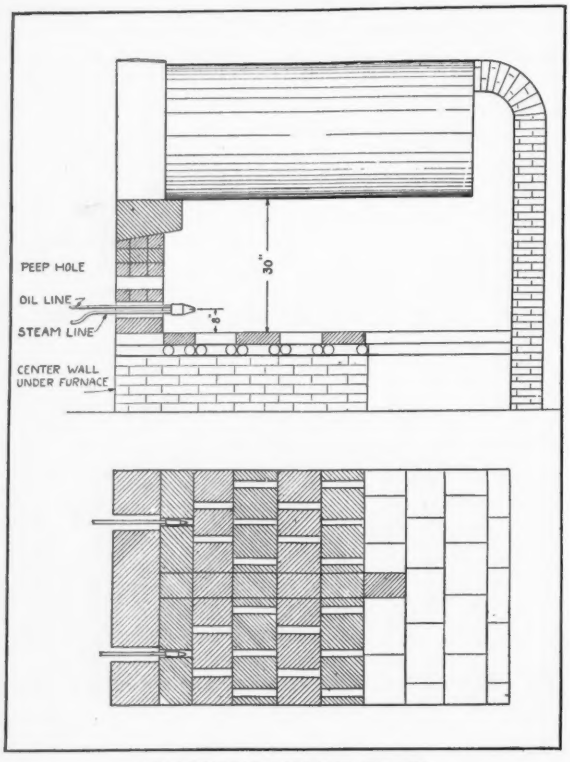
This tool is shown in the accompanying sketch. The standard type of scale is fitted with two legs, one of which is held in a fixed position while the other slides endwise when adjusting it to the part being measured. As will be obvious, the tool is checked by bringing the points of the legs together, under which conditions the scale reading will be zero. While the drawing is not dimensioned, it will be understood, the proportions are dependent on the length of scale, or in other words, the offside extensions of the legs will be longer for a large caliper. Make the offside extension about half the largest diameter on which the tool will be used and the body will clear a circular bar when gaging diameters.

Washington, D. C. G. A. LUERS.

PROBLEMS IN OPERATING POWER EQUIPMENT

Oil Burning Installation

I WOULD like to have the opinion of the readers of Power Plant Engineering as to the suitability of the oil burning installation shown in the accompanying sketch. After one unsuccessful attempt on the part of another designer this design was submitted. This is a two-burner setting for a 72-in. by 18 ft. horizontal return tubular boiler. I use a tight brick wall lengthwise

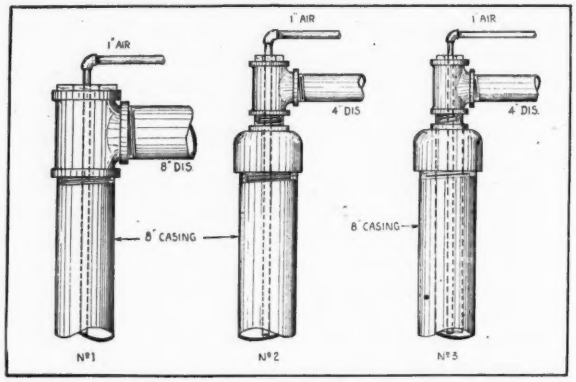


OIL BURNING FURNACE DESIGN

of the ash pit, in the center. For light loads I close up one side air-tight, and use only one burner. Each air opening is 2 by 9 in. I am using no bridge wall whatever. The furnace and combustion chamber floor is level. J. O. S.

Which Type Well Will Be the Most Economical?

I WOULD like to have the opinions of your readers as to which of the three casing heads shown in the accompanying sketch will be the most economical in operation for deep well air lift equipment. In well No. 1, the casing is used as the discharge pipe; there is no reduction in size, the 8-in. pipe being continued to the cistern where water is stored. In the No. 2 well, the casing is capped and the cap tapped to take a 4-in. pipe which serves as the discharge to the cistern. Number 3 has the discharge pipe extended down into the well just below the air nozzle. All three wells



WHICH OF THESE WELLS IS THE MOST ECONOMICAL?

have the same characteristics, same air line and same type of air nozzles.

I am now using arrangement No. 2 and getting all the water we require, but I would like to reduce the cost, if possible. C. D. R.

Collapsing Strength of Shells

PLEASE ADVISE me as to the kind of formula to be used in figuring the strength of the top and bottom tube sheets as shown in the accompanying sketch. Is it permissible to have tubes act as stays? Will the ordinary method of rolling in tubes provide sufficient strength? P. M.

A. In answer to your question as to whether or not the tubes shown in your sketch can be made to act as stays, it may be said that, if the tubes are either flared or beaded over and if the pitch is not excessive, they may be used for this purpose. This is the practice followed by manufacturers of fire-tube boilers.

There is, however, another point which suggests itself and that is the question of the strength of the wall and casing. One empirical equation for the strength steel shells as is used for the wall is

$$P = 65{,}720{,}000 \times t^3 \div D^3$$

from which by transposition we have

$$t = D \sqrt[3]{P \div 65{,}720{,}000}$$

In this equation t is the wall thickness in inches. D the diameter of the shell in inches and P the collapsing pressure. The pressure difference acting on this shell is approximately 30 lb. and a factor of safety of 7 or 8 should be used. We may take P as, say $8 \times 30 = 240$ lb.

D is, of course, 48 in. as indicated. Solving then for t we find

$$t \div 48 \sqrt[3]{240 \div 65{,}720{,}000} = 0.74 \text{ in. or, say } \tfrac{3}{4} \text{ in.}$$

For the outer cast iron shell a rational equation for the collapsing pressure is

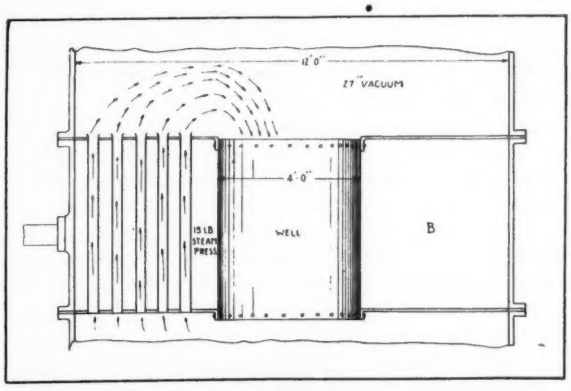
$$P = 2E \div (1 - m^2) \times t^3 \div D^3$$

where E is the modulus of elasticity which for cast iron may be taken as 12,000,000 and m is Poissons' ratio which may be taken as 0.27. The diameter in this case is 12 ft. or 144 in. and the pressure difference is approximately 15 lb. Assuming a factor of safety of 8, we have $P = 8 \times 15 = 120$ lb.

Transposing this equation and substituting known values, we have

$$1 = 144 \sqrt[3]{(1 - 0.27^2) \times 120 \div 2 \div 12{,}000{,}000} = 2.4 \text{ in.}$$

A wall 2 in. thick would give a factor of safety of about 5.



HEAT TRANSFER APPARATUS DESIGNED TO WITHSTAND BUCKLING STRESSES

Another point that will require attention is the head on your 12-ft. diameter shell. Roughly the pressure acting on this surface is atmospheric. If it is entirely unstayed, the working pressure is given as

$$p = 3f t^2 \div 2r^2$$

where p is the pressure, f the allowable working stress, t the thickness in inches and r the radius in inches. Transposing, we have

$$t = \sqrt{2r^2p \div 3f}$$

Using a factor of safety of 8, f, for cast iron will be about $20{,}000 \div 8 = 2500$; and we may write

$$t = \sqrt{2 \times 72^2 \times 15 \div 3 \div 2500} = 4.6 \text{ in.}$$

Where Should the Pump Be Located?

We are at present pumping water from a cistern to an elevated tank located about 360 ft. from our boilers; the pump takes steam from a line 460 ft. long, at 80 lb. pressure. Would it prove economical to install this pump at the boilers where it may be operated on 130 lb. pressure? In this case, it would be necessary to run a 4-in. suction line to the cistern and a 3-in. discharge to the tank; both would be about 360 ft. long. The object of this arrangement would be to avoid condensation in a 100-ft. steam line that is tapped from a steam main between the boiler room and our main building.

I do not want to go to the expense of installing the two water lines mentioned unless a material saving in fuel would result. For very good reasons, we can not move either the cistern or the tank so that they will, in any event, have to remain in the present location.

I should appreciate having the opinions of readers as to the savings that may be effected by making this change. C. P. R.

Cutting in Boilers; Pressure Gage Construction

Referring to the question by R. W. on page 391 of the April 1 issue, I would advise that the valve next the boiler be opened first. This should be a globe type valve, so installed as to close toward the boiler, or against the boiler pressure. The second valve may be either a gate or globe type, but if the latter, it should be installed to close toward the boiler the same as the first one. Pressure from the header will be on top of the disc of this valve, making it difficult to open until the one next to the boiler has been opened, thus equalizing the pressure above and below this disc. Even if this is a gate valve, it will be found difficult to open, until the one next to the boiler has been opened, so as to equalize the pressure on both sides of the gate. Always open the valve next to the boiler first, when cutting in a new boiler onto a line that is already carrying a head of steam.

As to the calibrations on the steam gage: it is always customary to place the stop at the first point of division, rather than at the zero point, so that the pointer will rest against it with sufficient pressure to prevent vibration, which would materially shorten the life of the gage, and would be a detriment in keeping the gage in proper adjustment.

Loma Linda, Cal. J. M. Row.

Relation Between Ammonia Pressure and Temperature

In the discharge line of an ammonia compressor what should be the temperature of the discharge gas corresponding to pressures of 150, 160, 170, 180 and 200 lb? What would cause a discrepancy between the temperature and pressure readings? C. D.

A. If it is assumed that only pure ammonia gas is being discharged from the compressor, inasmuch as this gas is in contact with liquid ammonia in the condenser, there will be a definite relation between the pressure and temperature. Thus we find in an ammonia table that the temperatures corresponding with the pressures you have given are 78.5, 82.3, 85.9, 89.4 and 95.9 deg. F. respectively. If the pressures and temperatures are read at the compressor, the temperature may be higher than would be indicated by the figures given, owing to the fact that the vapor is superheated. The pressure may also be higher than the condenser pressure owing to the pressure drop in the discharge piping.

Should the ammonia contain nitrogen or hydrogen, caused by the decomposition of the ammonia or air, the pressure would register higher in relation to the temperatures than the above ratio would indicate.

Correction Note

In an article by G. A. Hubbard on page 599 of the June 1 issue, there is reference to steam consumption in a uniflow engine. This is a misprint. The question deals with the steam consumption in a turbine.

POWER PLANT ENGINEERING

Trade Mark, Reg. U. S. Pat. Office

Published by the Technical Publishing Co.

537 South Dearborn Street, Chicago.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879. Issued the 1st and 15th of each month. Established over 28 yr.

Subscription price $2.00 a year in the United States and all its possessions. Canada $2.75 a year. All foreign countries $3.50 a year.

Copies of current issue, 15 cents; of back issues, 25 cents.

Copyright, 1923, by Technical Publishing Co.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

New York Office, 150 Nassau St.

Circulation of this issue 20,100

CONTENTS

New Johns-Manville Power Plant Designed by Staff Engineers. Illustrated 609

Drying of Moist Fuels Outside of the Furnace. By Zuce Kogan. Illustrated 619

Purchased Power Proves Expensive in Hotel. Illustrated 622

Uniform Costs for Power Plants—I. By Alfred Baruch 623

Heaters for Hot-Blast Work—II. By Charles L. Hubbard. Illustrated 626

Stresses in Tubes for High Pressure Boilers. Illustrated 629

Steps in De La Vergne Oil Engine Development. Illustrated .. 630

Lignite Burning Studied by South Dakota 632

Non-Inductive Alternating-Current Circuits. By E. K. McDowell. Illustrated 633

World's Largest Guided Radio Line on Pit River System. By Chas. W. Geiger. Illustrated 636

Design Features of New 1200-Lb. Boilers. Illustrated 637

Improvements Reduce Waste. By H. A. Jahnke. Illustrated .. 638

How the Leaks Were Stopped. By W. F. Schaphorst. Illustrated 639

How to Use the Mollier Ammonia Chart. By James R. Randolph. Illustrated 640

Letters Direct from the Plant: Boiler Furnace Design. Oil Grooves on the Journal. Phasing Out Alternators. Centrifugal Tension in Belting. Stop Valve at Boiler Outlet Is Unnecessary. Direct Reading Scale Caliper Attachment. Illustrated 644

Problems in Operating Power Equipment: Oil Burning Installation. Which Type Well Will Be the Most Economical? Collapsing Strength of Shells. Where Should the Pump Be Located? Cutting in Boilers; Pressure Gage Construction. Relation Between Ammonia Pressure and Temperature. Illustrated 648

Editorial: Pressure-Mania? Future Progress Depends on Today's Work 650

Off Duty 651

High Pressures to Change Station Design 652

Engineers in Maple-Leaf Land 653

American Society of Heating and Ventilating Engineers Meets in Chicago 655

Boilers with Stokers of Extraordinary Length Installed by Interborough 655

Strainer May Be Cleaned Without Interrupting Flow 656

Red Line Facilitates Reading of Mercury Thermometers 656

Admiral Robison Tells How Navy Reduces Power Cost 657

Power Generated by Wood Refuse 657

News Notes 657

Books and Catalogs 658

Pressure-Mania?

When the American Society of Mechanical Engineers met last December, higher steam pressure and temperatures came in for a great deal of discussion. The pressures considered, however, were around 600 lb. with brief mention of 1200 lb. A survey of this year's Prime Movers Committee report of the N. E. L. A. also mentions pressure of 1200 lb.

It is quite natural, therefore, that engineers, many of whom are in close contact with power plant development work, should be flabbergasted by the wave of pressure-mania which now holds the center of attention in station design. First came the news of 1500-lb. boilers in Sweden, then the announcement of actual construction of 1200-lb. boilers in this country. As if these figures were not sufficiently spectacular, comes the news from England of an experimental 3200-lb. boiler installation.

This is a bit too fast for the practical engineer—this jump from 600 lb. to 3200 lb. almost before the ink is dry on the Prime Movers Committee report. Quite interesting and very fine for the theorist, say the operating and designing engineers; but not so fast—let's take this pressure business a step at a time. If 1200-lb. boilers will pay their way then we can talk about 3200-lb. pressures.

History of progress in almost every line shows that development proceeds by spurts which sometimes carry it past the practical objective. Possibly that is what has happened in the consideration of high pressures. It may be necessary to retrace some of the steps before general adoption of these higher pressures and finally arrive at the stopping place demanded by present limitations of materials and design.

In any case, the study of high pressures offers a field of interesting possibilities. At least the 1200-lb. point has now reached the experimental stage in this country. Several installations will be made in the near future, with the Commonwealth Edison Co. of Chicago and the Edison Electric Illuminating Co. of Boston as pioneers. At the same time, the Babcock & Wilcox Co. deserves no little credit for the advancement of this work from the theoretical to the experimental status. No doubt the next step will be that of practical proof.

With such organizations behind high pressure work, this rapid development can hardly be classed as pressure-mania and yet too much emphasis should not be placed on the spectacular. It is so easy to say 3200 lb. and to show its advantages on paper, but such advances do not spring into full being overnight.

Future Progress Depends on Today's Work

When we speak of pioneers, our first thoughts generally are of those men who pushed forward across the plains and mountains in the work of exploration and development which eventually brought about the elimination of our frontier.

The engineering profession, however, has its pioneers, for it was the engineer of yesterday whose work in the foundation upon which much of our present knowledge and practice is based. He made mistakes as will the engineer of today, but the material loss may be overlooked because the effect has added to the general store

of knowledge useful for future development. The pioneer engineer required and developed the attributes of foresight, conviction and courage which were also predominating characteristics of the sturdy and fearless frontiersman.

It is these same characteristics which must predominate today because our work will in time be looked upon as that of the pioneer. The best that can be given to the world today will be the foundation upon which great engineering work will be done in the future. Transmission of electrical current at high voltages, the generation of steam at high pressures, the conservation of fuel, the design of new and larger power units are but the work of the present which tomorrow will have become the work of the pioneer.

Every opportunity should be taken advantage of by the present day engineer to advance engineering knowledge and accomplishment so that those who come after may build upon and accomplish more important and valuable work that civilization may be served the better and that man may build progressively.

Off Duty

There is considerably more truth than poetry in the remark that the only thing that is constant in the universe, is change. Change is the underlying factor in all the evolutionary processes of nature, and it is therefore not at all strange that our ideas in regard to things change as time goes on.

In 1835 it took approximately 5 mo. to go from Boston to California, by way of Cape Horn. A roundabout way, to be sure, but even at that it was almost as quick as going overland by way of the prairie schooner. The people living at that time did not think 5 mo. unusually long.

Today, we have different ideas in regard to a transcontinental trip. Just the other day, two men climbed into an airplane a few miles outside of New York City and 27 hr. later climbed out of that same machine at Los Angeles, California. In 27 hr. they had done what it took 5 mo. to do in 1835!

And now comes Georges Barbot with his flying flivver who calmly proposes to fly from New York to Chicago for total cost of less than three dollars. Amazing as it may seem, we do not doubt it. We have grown so accustomed to marvelous feats of modern science that nothing disturbs our equanimity.

Flexible as our minds have become towards the kaleidoscopic changes wrought by modern civilization, we are today confronted with a problem which will tax our powers of thought to no inconsiderable degree. We are on the verge of a new era of scientific thought which will require a rearrangement of our ideas of nature and the universe.

In the days before Copernicus, the earth was, so it seemed, an immovable foundation on which the whole structure of the heavens was reared. Man, favorably situated at the hub of the universe, might well expect that to him the scheme of nature would unfold itself in its simplest aspect. But the behavior of the heavenly bodies was not at all simple; and the planets literally looped the loop in fantastic curves called epicycles. The cosmogonist had to fill the skies with spheres revolving upon spheres to bear the planets in their appointed orbits; and wheels were added to wheels until the music of the spheres seemed well-nigh drowned in a discord of whirling machinery. Then came one of the great revolutions of scientific thought which swept aside the Ptolemaic system of spheres and epicycles, and revealed the simple plan of the solar system which has endured to this day.

Everyone now admits that the Ptolemaic system which regarded the earth as the center of all things, belongs to the dark ages. To our dismay, however, we have discovered that the geocentric outlook still permeates modern physics through and through, unsuspected until recently. It has been left to Einstein to carry forward the revolution begun by Copernicus—to free our conception of nature from the terrestial bias imparted into it by the limitations of our earthbound experience.

Eight years ago, Einstein satisfied himself that the heavenly bodies behaved in accordance with the results of his equations. He stated that certain things were so, and since then has manifested the least anxiety of any as to the truth of his deductions. He had full confidence in his equations. The world at large, however, including scientific bodies, was not content to accept Einstein's word and since then every effort has been made to prove his theories experimentally.

This has finally been done, so conclusively, in fact, many of the leading scientific centers announce that no further expeditions will be sent out to observe future eclipses of the sun. So far as they are concerned, the theory has been confirmed. Einstein's predicted deflection of 1.75 sec. of arc, of a ray of starlight grazing the sun's disk, has been found to exist. Dr. Campbell's measurements in the recent Australian expeditions, show the average deflection of light from a large number of stars to be 1.74 sec. of arc. These measurements of Dr. Campbell's photographic plates were made by different astronomers who could not know what the result would be until they were finally figured out. Check plates taken of other stars show that the displacement images can not be due to any defects of the telescope or sensitive plates.

Thus, the Einstein theory becomes a fact, and with it come new ideas. In the same manner that those living in the time of Copernicus had to alter their views of the earth and its relation to the solar system, so do we now have to alter our views of the world and space. A similar revolution of thought is needed.

Above, we referred to the changes of modern civilization. With a changing world we must have changing standards—changing ideas. The laws of Newton are still good; they need not be discarded. They must be amended, however, for they do not apply to all possible cases. Without our knowledge, we had been applying the laws of Newton to only a special case and not to the general case for which only the Einstein theory holds true.

The change of ideas necessary today as a consequence of the confirmation of Einstein's theory will be brought about with far less effort or opposition than was the case in changing over from the Ptolemaic to the Copernican system. Today the world is accustomed to think more along scientific lines and the dogma which so retarded scientific progress in the dark ages is practically non-existent today.

High Pressures to Change Station Design

CONSENSUS OF OPINION AT NATIONAL ELECTRIC LIGHT ASSOCIATION CONVENTION IS THAT NEW PRACTICES WILL HAVE MARKED EFFECT ON STATION ECONOMICS

UNUSUAL DEVELOPMENTS in power plant design, particularly those brought about by the use of higher steam pressures, stage feed water heating, air preheating and the use of pulverized fuel, received the most attention and evoked the most discussion at the 46th convention of the National Electric Light Association at New York on June 4 to 8. It was the opinion of all the speakers at the sessions of the technical section that the economies to be effected by the use of higher pressures would mean radical departures from previous practices.

Probably the most interesting of the discussions on this subject was that of Charles H. Mertz, consulting engineer of the firm Mertz and McClellan of London, England. In 1917 Mr. Mertz designed the North Tyes plant for 550-lb. boilers, stage feed heating, reheating and air preheating. He pointed out that no difficulties had been experienced in the operation of this station which would warrant a statement that high pressures are not practicable. In his opinion, no more trouble has been experienced with air preheating than with an economizer, although at the time the station was designed many engineers predicted trouble with the chain grate stokers due to the use of high temperature air. As the condenser is where most of the heat loss is encountered, the thing to do, according to Mr. Mertz, is to take out as many heat units for feed water heating as possible. This means stage heating of feed water by bleeding the turbine. If the feed water is to be heated by steam, then some other use must be made of the heat in the flue gases. For this reason the development of air preheating has come about. Mr. Mertz, therefore, asserted that there was no question of comparing economizer performance with air preheaters. If air preheating is used, the economizer is supplanted because of feed water heating with steam.

USE OF HOUSE TURBINE NOT JUSTIFIED

Attention was also called to reheating the steam after the initial superheat had been lost. This same general scheme had been employed in the plans for the 1200-lb. pressure units which were announced recently by Chicago and Boston companies. In Mr. Mertz's opinion, it is not possible to justify the use of house turbines. Why, he asked, should we go to so much trouble to gain a small percentage increase in efficiency of the main units and then throw a part of this away through the use of comparatively inefficient house turbines? If for the sake of increasing the factor of safety it is necessary to use a separate generator, then this should be direct connected to the main unit.

He also advocated a study of the possible use of internal combustion engines to drive house generators. In this way it would be possible to take advantage of a unit thermodynamically as efficient as the main units. It was his belief that central station engineers have not given sufficient attention to the use of internal combustion engines for such purposes.

KILOWATT-HR. PER POUND OF COAL IS GOAL

With higher steam pressures and improved station economies, the goal of power plant designers is the production of a kilowatt-hour for a pound of coal, stated Frederick N. Bushnell, manager of the division of construction and engineering for Stone & Webster, in his talk of higher steam pressures and station economies. He pointed out that there is little advantage in using higher steam pressures in the regular cycle because the temperatures cannot be raised sufficiently high to prevent excess moisture in the lower stages. It is necessary to reheat the steam by returning it to the boiler and passing it through a secondary superheater. This general scheme is quite similar to use of a reheater in reciprocating service except that the steam is reheated in the boiler furnace instead of by steam. For the 1200-lb. cycle, he asserted that the saving would be about 10 per cent.

Prof. A. G. Christie, of Johns Hopkins University, in his talk on "Pulverized Fuel in Central Station Boiler Rooms," warned of the danger in the too rapid use of pulverized fuel equipment under unfavorable conditions. He thought that all of the factors should be carefully considered before arriving at a decision. In his opinion pulverized fuel equipment is now as reliable as stoker equipment with possibly the exception of certain grades of anthracite. He also pointed out a number of the advantages of this type of fuel-burning equipment such as the ability to burn low grade fuels with high ash content and low fusibility. The fact that the load can be picked up more quickly also has an economic value.

Peter Junkersfeld, consulting engineer of McClelland and Junkersfeld, Inc., contributed a word of caution about using new equipment unless the probable life of the equipment and the capacity factor were taken into consideration. In his opinion, equipment may be scrapped and new equipment installed only after a

careful study of present and future conditions have shown that it will pay. Engineers should be dollar savers as well as B.t.u. savers, he asserted.

All of these addresses were given in connection with the first session of the Technical National Section, on June 4, with Chairman R. F. Schuchardt, electrical engineer of the Commonwealth Edison Co., in charge. At this session the prime movers' committee report was presented by Chairman C. F. Hirshfield of the Detroit Edison Co. O. G. Thurlow, of the Alabama Power Co., as chairman of Hydraulic Power Committee, presented the report of that body. R. H. Tapscott, New York Edison Co., chairman of the Electrical Apparatus Committeee, gave an outline of the work of that committee.

At this same meeting H. Birchard Taylor, vice-president of William Cramp & Son Ship and Engine Building Co., compared American and European hydroelectric developments, asserting that this country had now outdistanced Europe in the magnitude, number and scope of such developments.

Use of synchronous motors for power station auxiliaries was pointed out by R. A. Hecht as being feasible. F. C. Hanker, of the Westinghouse Electric & Manufacturing Co., also talked on the subject of synchronous motors for auxiliary drives, stating that many industrial applications had been made, requiring similar characteristics such as high starting torque and the ability to pick up the load in case of an interruption.

Most failures of metal at high temperatures have been due to the use of poor grades of material, stated V. T. Malcolm, of the Chapman Valve and Manufacturing Co. Where clean steel of high quality is used, no trouble should be experienced at 800 deg. F. He stated that experiments had shown that steel at 1000 deg. F. had an elastic limit of 21,000 lb. and a tensile strength of 53,000 lb. From the valve standpoint 1200 lb. pressures and temperatures of 1000 deg. F. are entirely feasible.

Jungren, of the General Electric Co., stated that considerations of temperatures and pressure are purely relative. What was considered unusual a few years ago is standard practice today and the high pressures of today may be looked upon in the same way a few years hence. It was his belief that while a good deal of attention had been given to mechanical stresses, not enough attention had been given to temperature stresses.

In the scheme of using a high pressure turbine as a reducing valve, it has been considered necessary to use a method of reheating the exhaust steam before passing it into the next unit, stated F. H. Hodgkinson, of the Westinghouse Electric and Manufacturing Co.

Florey, of the Allls-Chalmers Co., called attention to the 20,000-kw. unit which their organization is building for the Waukegan Station. This is the first unit of that size built by Allis-Chalmers.

At the second session of the Technical Section on June 5, the future substation was discussed by C. W. Stone, of the General Electric Co., and Philip Torchio, of the New York Edison Co, talked on "Emergency Interconnection Between Foreign Companies." Alex Dow, president of the Detroit Edison Co., pointed out the value of bulk supply to industry in his address.

This year's convention came up fully to those of preceding years and many optimistic comments were made regarding the engineering development of the Central Station Industry as well as the prospects for a banner year business.

Engineers in Maple Leaf Land

FINE TECHNICAL PROGRAM AND INTERESTING EXCURSIONS MAKE SPRING MEETING OF A. S. M. E. AT MONTREAL GREAT SUCCESS

CANADA, which has as its charming symbol the maple leaf, regular, symmetrical, yet diversified and artistic, gave royal welcome to United States engineers at Montreal May 28 to 31. Technical papers of vital interest, excursions to magnificent engineering developments and well ordered social functions combined to give a profitable and pleasant meeting which will long be remembered as a bright spot in the experience of those who were there. Monday was largely a day of routine business, but the talk by Secretary Calvin W. Rice, telling his experiences on his trip to visit engineers of South American countries, showing views of the homes of engineering societies in the capitals of those countries and giving the positions of honor and trust in civic affairs which engineers hold there, brought a vivid realization of the standing to which engineers have attained in other lands, and to which the engineers of North America should aspire.

New sections of the American Society of Mechanical Engineers were authorized by the Council for the State of Utah, at Salt Lake City for the Carolinas with branches at Charlotte and Raleigh, N. C., and at Greenville, S. C., and for Eastern Tennessee at Knoxville.

It was recommended that the Professional Divisions activities be reorganized by combining divisions having allied interests so as to leave 8 to 10 fundamental divisions such as Power, Shop, Transportation, National Defense, etc., with committees of divisions looking after special branches of work such as Fuels, Gas Power, Oil Engineering and Conveying of Materials.

B. T. U. Society of Brown University was accepted as an affiliated student society and student branches were authorized at University of Tennessee and the University of Vermont.

CANADIAN POWER DEVELOPMENT

Papers of direct interest to power plant engineers were presented at the session on Tuesday morning relating to development and transmission of power in the provinces of Quebec and Ontario. These gave in detail the history of the development of the water powers in these provinces and showed how this has been by a well conceived plan, based on careful surveys of the power possibilities of the rivers, many of the surveys being made long before plans of development were proposed.

It was shown that in Quebec, having 25 per cent of the area of the United States, the continuous water power available is 12,000,000 hp. at 50 per cent load factor. Progress has been made from 5000-hp. units

in 1911 to 43,000-hp. units in 1923, with efficiency running above 80 per cent from 45 per cent load up to 100 per cent load.

Storage and control reservoirs are owned and operated by the government for the best interests of all power companies. An example of plants is the development on the Saguenay River where 300 ft. is to be utilized in two levels, the first to give 400,000 hp. and the second 800,000 hp., the former plant to be ready in 2 to 3 yr. It is estimated that 1,070,000 hp. is now developed and operating in the province, and that the undeveloped capacity available is 5,125,000 hp., all of which will be needed in 20 to 25 yr.

In Ontario some 6,000,000 hp. is available, of which 1,300,000 hp. is developed. In the early developments at Niagara, where the plants were located near the falls, the over-all efficiency was about 80 per cent. At the Queenstown-Chippewa plant, where water is taken by a 12.5-mi. canal from the Niagara River to near Lake Ontario, 294 ft. of the full 310-ft. head is used and the over-all efficiency is 90 per cent, ten 60,000-hp. units being planned, to deliver about 800,000 hp.

All development is in the charge of a power commission, which looks after the needs of small communities as well as large, and has developed an interconnected system so that power can be transferred according to needs of the districts and condition of the streams from one section of the province to another.

It is interesting to note that because of the distance from east to west in the interconnected system, some 800 mi., the time of maximum flow of the streams varies, western streams having their flood season earlier in the year than eastern, so that the period of excess power is lengthened and of low power shortened by this interchange. Also, because of the difference in time, the peak load comes at different hours on different parts of the system, and interchange of power improves the load factor of the system.

In the discussion it was emphasized by Mr. Darlington, Mr. Freeman and Mr. White that the free use of power is a great factor in prosperity; that the engineer is expected so to develop the power resources of a country as to lead to a maximum of comfort and a minimum of toil, and that the reason better returns are received by workmen on the American continent than in Europe or Asia is largely because the use of power multiplies their ability to produce.

In answer to questions it was stated that in some plants, water which would otherwise be wasted, was used to produce current used in electric steam generators as large as 2000 to 3000 hp., and that the return can be reckoned as on the basis of $13 per hp.-yr., figuring coal at $10 a ton, and 1 T. of coal as equal to 5000 kw.-hr.

Boiler Operating Rules

Quite complete suggestions for safe operation of boilers were presented by a sub-committee of the Boiler Code Committee at a hearing on Tuesday afternoon, and the substance of these with changes suggested will appear in a later issue.

Large Hydraulic Turbines

Modern practice in these units was taken up at the second power session on Wednesday morning. Mr. Acres defined "large" turbines as those having a capacity over 25,000 hp. and for heads of over 60 ft. The problems with such units are due to the static head and overpressure from surges in long penstock lines and support of the weight. The solution of these problems has been possible because of the Johnson valve, designed on an enlarged needle valve principle, the Johnson differential surge tank, and the Kingsbury thrust bearing.

For horizontal turbines 20,000 hp. has been found to be about the maximum. But with the vertical type, it has been possible to go up to 55,000 hp. per unit, and 70,000-hp. units are now being built for the Niagara Falls Power Co.

Operation at point of best efficiency was advocated for turbines which may be so designed that their maximum output is above that point. For the 55,000-hp. units at Queenstown, which have a best over-all efficiency of 90.5 per cent, a loss of 1 per cent in efficiency means wasting enough energy in the five units to supply a city of 10,000 population. Hence a gain or loss of a fraction of a per cent becomes a serious matter. The use of the Johnson devices makes it possible to control the flow of water in pipes up to 22 ft. diameter without surges, yet get close governing and tight seating.

Use of the spread draft tube was discussed by Professor Angus, Mr. Moody and Mr. White. The center cone extending up to the hub of the wheel showed, under tests, the best efficiency of any form, and while it was admitted that the Hydraucone without a center filling cone would show as good efficiency, the center cone was deemed to have an important value in reducing vibration, which is a serious factor in large plants. The spread draft tube was thought to be as important for low head as for high head plants.

In the Kingsbury bearing are embodied the principles of self-adjustment for slight lack of parallelism of surfaces, automatic creation of a lubricating film of wedge shape with the thick edge at the incoming side, long life and freedom from complication.

Other factors which have contributed to development of large turbines are methods of measuring flow of water in penstocks which are accurate to a remarkable degree and are free of complication on empirical constants in application. Professor Allen stated that by taking measurements of pressure above and below the Johnson valve and record its position when making tests by either the pressure method or salt-velocity method, it is possible to calibrate the valve as a Venturi meter so that continuous record of input can be secured while operating, and the operating efficiency checked at all times.

High-Pressure Steam Control

In his paper on Sectionalization and Remote Control of High-Pressure Steam Lines, Mr. Dean, giving the layout used in several large stations, emphasized the importance of providing every possible safeguard against failure and precaution to prevent injury to persons and damage to the plant in case of accident, without requiring any employe to risk his safety.

No attempt will be made in this report to give the details of Mr. Dean's paper, as this will be published in the July 1 issue of Power Plant Engineering. In the discussion of the paper, however, Mr. Pigott stated that

neither globe nor gate valves seemed well suited for quick closure under high pressure, and possibly something like the Johnson valve might be developed. As pressures go to 500 to 1200 lb., it will be necessary to find a metal for valves and seats which will stand high temperature without deformation and yet have a quality of bearing metals so that it will slide without abrasion or excessive friction. Also the seats and their housings must have nearly the same coefficient of expansion to avoid distortion and displacement.

Chimney Proportions

Thursday morning session on Fuels was notable for the paper by Mr. Cotton devoted to chimney sizes. He showed that the proper method of design is based on the volume of gases to be handled; that maximum capacity depends on area and is independent of height; and that static draft depends only on height and is independent of diameter; and the draft available at the base of the chimney, for moving gases through the boiler structure depends on the amount of gases to be moved. Charts were given for the static draft for chimneys 0 to 500 ft. high with gas temperatures from 100 to 1200 deg. F. at 60 deg. atmospheric temperature and sea level. The methods of connecting for other atmospheric temperatures, for barometric pressure and for mean gas temperature were shown also by curves. Other factors are gas velocity, resistance of fuel bed, resistance through the boiler, all of which were discussed and reduced to curves. Examples were worked out showing the use of the curves and how to determine the least expensive of a number of possible combinations of height and diameter which would give the required capacity for a given set of conditions.

Lignite char as discussed by Mr. Hood will also be treated in a future issue of Power Plant Engineering.

Heating and Ventilating Engineers Meet in Chicago

With a record breaking attendance of over 500, the American Society of Heating and Ventilating Engineers held its semi-annual meeting at the Drake Hotel, Chicago, May 21 to 23. After the usual formalities, Monday morning, the meeting was given over to the report of various committees. A standard code for testing fans was submitted at this session and adopted. The code for heating and ventilating equipment was presented in outline form for discussion at the afternoon and evening sessions for suggestions and discussion.

Tuesday was given over to reports of work that had been done at the research laboratories. Papers were presented on the use and detection of ozone and on dust determinations. In the afternoon, papers were read on heat transfer and combustion in a small domestic boiler, and on the study of physiological reactions under various air conditions. A paper by F. C. Houghton and C. P. Yagloglou on the determination of the comfort zone of air conditions with verification of effective temperatures within this zone aroused much interest which seemed to center around the question of the determination of the so-called effective temperature.

The term effective temperature is a new one in engineering literature and connotes a physiological reaction. It is not a definite condition like the dry bulb temperature that can be measured by a thermometer nor is it comparable with wet bulb temperature which when you come to think of it is not a concrete thing but is rather an indication of a condition under certain hypothetical circumstances. It is, however, dependent upon these two temperatures. At ordinary dry bulb temperatures, both the wet and dry bulb temperatures have about equal effect in determining the effective temperature. As the dry bulb temperature rises, it has less and less effect on the effective temperature and at a dew point of 132 deg. it depends entirely on the wet bulb temperature. As the temperature falls, the dry bulb has more effect upon the effective temperature until at the freezing point, it is entirely independent of the wet bulb. The relation between these three temperatures has been determined experimentally for a number of different conditions and the results plotted on a psychometric chart. At present there is no mathematical expression for this relation, but it is hoped that one will be evolved in the near future.

"Insulation of cold surfaces to prevent sweating," was the first paper presented at the heating session Wednesday morning. The author, L. L. Barrett, evolved a mathematical relation for determining the extent of insulation necessary to prevent condensation of the surface under various conditions of temperature, humidity and air movement of the surrounding air. This was followed by a description of the heating system of the Chase Metal Works. Papers on register temperatures of warm air systems, and on the progress of district heating in Boston, concluded the session.

At the ventilation session in the afternoon, S. R. Lewis reported briefly on the Ventilation Code of the State of Wisconsin on which there was no official discussion.

Mr. Howatt presented a paper dealing with the heating and ventilating system now being used in the public schools of Chicago.

The report of the New York State Commission on Ventilation was presented for discussion. Several antiquated methods were proposed in this report and the criticism on this part in particular and the whole report in general was rather severe.

Boilers with Stokers of Extraordinary Length Installed by Interborough

Changes in the boiler equipment of the Interborough Rapid Transit Co.'s 59th St. Station in New York City are under way, which will involve the addition to the present installation of two boilers this summer and two more next year. The plans are of special interest because of unusual dimensions adopted for the Taylor stokers, which while of standard width of seven retorts are to be 37 tuyeres long, extending the whole length of the boilers and exceeding in this dimension any other stokers of this type.

New units which are to be added to the present installation of 60—600-hp. boilers are to be of 1200-hp. rating, designed for 350 lb. gage pressure and 200 deg. F. superheat, although they will be operated for the present at 220 lb. gage pressure. Besides the innovations in stoker design, one of the boilers to be installed this year will have a radiant heat superheater of the Power Specialty

Co. The other three boilers will be furnished with standard Babcock & Wilcox superheaters.

In connection with these units, the Interborough company will for the first time employ motor driven auxiliaries. This change is in line with recent general practice. In order to maintain the heat balance at 59th St., it will probably be necessary to resort to bleeding from the main turbines.

The work is under supervision of H. A. Kidder, superintendent of motive power, and H. B. Reynolds, mechanical research engineer, of the Interborough Rapid Transit Co.

Strainer May Be Cleaned Without Interrupting Flow

THROUGH the use of three strainer baskets which may be rotated so that one can be cleaned while the other two remain in service, the Blackburn-Smith Corporation, of New York, has developed a strainer in

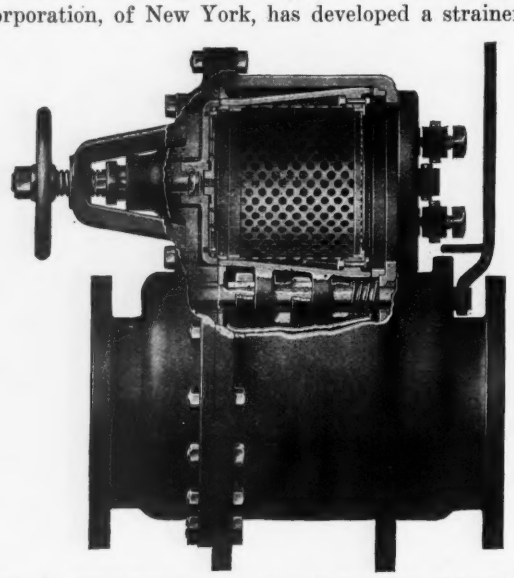


FIG. 1. STRAINER BASKET IN POSITION FOR CLEANING

which it is unnecessary to interrupt the flow of liquid when removing the collected solids. As shown in Fig. 1, the casing of the strainer is made in two parts, bolted together. An inlet nozzle at one end and an outlet nozzle at the other end are so located as to bring the piping connections in line.

Inner construction or strainer proper is shown in Fig. 2. Three cylindrical strainer baskets are securely held in three bell-shaped conduits equally spaced in a large circular plate. This plate is rotated in a groove provided at the joint between the two parts of the outer casing. Each of the three conduits has two lugs by which it is keyed to the central shaft which passes through a stuffing-box to the operating lever (right, Fig. 1). The end of the shaft is three-sided; the lever can therefore be shifted on the end of the shaft, allowing the strainer proper to be rotated exactly one-third of a turn at a time, bringing one fouled basket into position for cleaning and at the same time replacing it with a clean basket.

Due to the shape of the inlet post of the strainer, the entering liquid divides equally between the two conduits which are in service, the circular conduit plate compelling the liquid to pass through the conduits and thus through the strainer baskets. A valve arrangement is provided for completely shutting off from the flow of liquid the conduit containing the strainer basket to be cleaned. Opposite the valve is an opening in the outer casing, provided with a lid, through which the basket is removed for cleaning.

Assume that one conduit containing a strainer basket previously cleaned is in the cleaning position with the valve disc basket away from the end of the conduit and that two baskets have been in service long

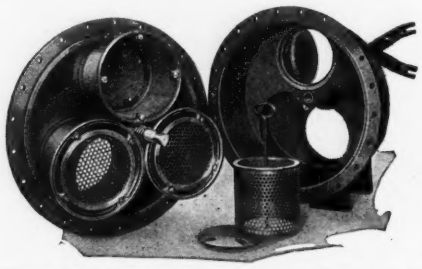


FIG. 2. IN CLEANING STRAINER ONE BASKET IS REMOVED AT A TIME, THE OTHER REMAINING IN SERVICE

enough to require cleaning. The operating lever is moved one-third turn, striking against a fixed stop and thus exactly alining one of the conduits containing a dirty basket in front of the valve arrangement. One turn of the hand wheel now seats the valve disc firmly against the small end of the conduit, and the other end of the conduit is forced against a seat on the inside of the outer casing, the travel being only ½ in. A closed chamber is thus formed by the valve disc, the conduit, and the lid which closes the opening in the outer casing, so that the liquid which is being strained through the other two baskets cannot enter and interfere with the cleaning.

After loosening and throwing back the Y-clamp, the lid is now opened. A removing handle is screwed into a circular revolving plate, which is held against the valve disc by spring latches, and four small bolts which hold the basket in the conduit are turned a half turn each. A quick pull on the removing handle releases the removing plate from its latches and brings it against the open end of the basket, forming a cover to prevent the contents of the basket from spilling as it is removed.

Red Line Facilitates Reading of Mercury Thermometers

IN ORDER to increase the visibility of the mercury in thermometers the C. J. Tagliabue Mfg. Co. of 88 Thirty-third St., Brooklyn, has recently brought out thermometers with a red reading column. This feature consists of a broad red line from the top of the mercury column to the top of the tube. When the mercury rises, it covers more of this red line and when the mercury falls a correspondingly greater length of the red line is visible. This red line attracts the eye at first glance and it is easy to follow it down and take the reading. This feature brings to the mercury thermometer the easy readability of the red spirit thermometer.

Admiral Robison Tells How Navy Reduces Power Costs

RECENT economies in fuel and other items in power production in his department formed the main feature of an address by Rear-Admiral John Keeler Robison, engineer-in-chief of the United States Navy, at a meeting of the metropolitan sections of the four national engineering societies on the subject "The Engineer in Public Affairs," held at the Engineering Societies Building on May 8.

Emphasizing the value of attention to instructions as issued, which he said were likely to be disregarded after the manipulation of machinery was mastered, the speaker cited an instance of a squadron in foreign water in which a reduction of fuel consumption of 32.3 per cent per knot under way and 49.7 per cent per day in port was effected within 4 mo. by simply enforcing the instructions from Washington without any other change in procedure. By such economies as this, $2,500,000 of the fuel appropriation for the current year will be saved. The average consumption for the navy, per kw.-hr. per mile under way or per day in port, was reduced by 12 per cent during the year ending June 30 last, and an additional saving for the current year will reduce the consumption on this basis to 78 T. for every 100 T. 2 yr. previously. Further work along the same lines is expected ultimately to bring the figure down to 60 per cent of the original.

By development of a system of self-maintenance in the fleet, by which the men on the job do their own work of this sort, the expenses for repairs, supplies, and maintenance have this year been cut to $1.35 per hp.-yr. as compared with $3.75 2 yr. ago.

Changes in Equipment Effects Economies

Recounting a number of instances of saving through changes in equipment, Admiral Robison said that by putting in a lot of small centrifugal oil purifiers on board ship they had cut the cost of lubricating oil to one-third of what it had been and saved over a half a million a year, the change paying for itself in about four months. Substitution of modern ice machines for good serviceable ones of antiquated type gave about 50 per cent more cooling effect and cost about half as much to run.

On the "Maryland," using exhaust steam instead of live steam for distillation of drinking and make-up water resulted in saving of fuel oil sufficient to pay for the change within a year. In general, there are so many things of this sort to be done that nothing is attempted on the economic basis which will not pay for itself within a year.

In the navy, the ultimate aim and application of all such work lies in the improvement of the efficiency of the fleet for battle, a prime factor of which consists in holding enough fuel aboard to meet all contingencies in the presence of the enemy. The most recent battleships can go 15,000 mi. without refuelling, when given the best conditions in all respects; but the fleet can only go as far as its least able unit, which at present is less than half that distance. It is hoped, however, to have all in condition within 2 yr. to go 10,000 mi. without refuelling.

Power Generated by Wood Refuse

AT CROSSETT, Ark., the Crossett Lumber Co. is just completing a new power plant the purpose of which is to serve its five saw mills at that point.

These mills are so grouped that the steam transmission lines, which carry one-third of the steam generated for kiln drying purposes, will range from 1000 to 2000 ft. in length. Southern pine, sawdust and shavings will be transported to the power house and will constitute the only fuel burned.

Six water-tube boilers, each rated at 500 hp., are to be operated at 225 lb. pressure and at 250 per cent of rating, with steam at 75 deg. F. superheat. These boilers are to be served by a single stack 14 ft. in diameter by 275 ft. high. Electric power will be generated at 440 v. and 60 cycles in three turbo-alternators of 1500-kw. capacity each and one turbo-alternator rated at 750 kw.

Three ponds are available for condensing water purposes; at present two of these ponds are tied together which gives approximately 65 acres of water surface which will be ample for cooling purposes without resorting to spraying. The condensing equipment will consist of surface type condensers.

Design and field supervision of this power plant are under the direction of the Sessions Engineering Co., Consulting Engineers.

News Notes

E. G. Allen, formerly chief engineer of the Philadelphia Rapid Transit Co., is now consulting engineer with Stone & Webster, Inc., of Boston, Mass.

Girtanner Engineering Co. has removed its offices from 30 Church St. to larger quarters at 1400 Broadway, New York.

Link-Belt Co., of Chicago and Philadelphia, announces that L. M. Dalton has succeeded E. J. Burnell as manager of the Boston branch office.

H. R. Sargent, formerly manager of the wiring supplies division of the Bridgeport Works of the General Electric Co., has been appointed managing engineer of this division under a development plan which will create several unit divisions at the Bridgeport factory.

J. J. McNulta, chief engineer for the Vacuum Ash & Soot Conveyor Co. for the past 5 yr., has resigned to assume a similar position with the Girtanner Engineering Corporation, of New York, N. Y., manufacturers of ash conveyor apparatus.

B. F. Sturtevant Co., of Hyde Park, Boston, Mass., has recently purchased the entire plant of the Wisconsin Engine Co., makers of Corliss engines at Corliss, Wis. The new acquisition covers nearly 10 acres and the buildings have approximately 150,000 ft. of floor space. A full manufacturing and engineering staff will be maintained and closer co-operation given to western customers. Shipping raw material east and the finished product west, adds a good deal to the ultimate cost because of freight charge. The situation at Corliss

will make a substantial reduction in these additional transportation costs.

Harry W. Page, who for the past 6 yr. has been assistant general manager at Hyde Park, has been selected as general manager and will be in entire charge of the Wisconsin plant.

CARL P. HUBBARD, formerly supervising engineer for Lockwood, Greene & Co. at Chicago, has left that organization and is now in the Chicago office of Stone & Webster, Inc., of Boston, Mass.

PALMYRA PACKING CO. was incorporated May 12, 1923, under the laws of the state of New York, with general offices and factories at Palmyra, N. Y. The officers of the company are John N. Todd, president, who was for 15 yr. general sales manager of the Garlock Packing Co.; Frank W. Coats, vice-president, formerly vice-president of the Crandall Packing Co.; Samuel H. Hunt, treasurer, and Charles McLouth, secretary.

FRANK E. WING, treasurer L. S. Starrett Co., Athol, Mass., died at his home in that city on May 13, aged 57 yr. Mr. Wing was born in Conway, Mass., and was educated in the public schools there and later at Smith Academy. He was graduated from Yale in 1886 with the degree. B. A. He came to Athol in 1887 and was employed by the late Laroy S. Starrett as bookkeeper. When the L. S. Starrett Co. was incorporated in 1900, he was made clerk and a director, which offices he continued to hold, together with that of treasurer, since 1912.

GEORGE ADAM RENTSCHLER, president Hooven, Owens, Rentschler Co., Hamilton, Ohio, manufacturer of the Hamilton Corliss engine, died at his home on May 24, aged 77 yr. He was born in Germany, coming to America with his parents when 3 yr. old. He lived for some time in Newark, N. J., and Peru, Ind., and moved to Cincinnati in 1870, where he entered the foundry business. In 1873 he removed to Hamilton and built the Dauscher foundry, then known as the Variety Iron Works. Later he became president of the Hooven, Owens, Rentschler Co., and in addition was also president of the Hamilton Foundry & Machine Co., and vice-president of the Phoenix Caster Co.

Books and Catalogs

THE LIBRARY OF POWER PLANT PRACTICE. Edited by Terrell Croft; 9 volumes, 3978 pages, 3778 illustrations, uniform cloth, gold titles, 8 by 5 in.; New York, N. Y., 1923.

The Library of Power Plant Practice is the result of 2 yr. of work on the part of a staff of engineers under the direction of Terrell Croft, and represents an unusually complete, accurate and up-to-date library of practical information. They cover every branch of power plant engineering and the material is presented in a clear and interesting manner.

It is splendidly adapted for either home study or reference—the books are self-teachers. Throughout the 9 volumes, the principles of modern power plant engineering are explained in such a way that anyone can understand them.

Each book is divided into sections and at the end of each division questions are asked, based on the text matter in the division just preceding. Where problems are given, detailed solutions will be found in the back of the books.

Drawings, of which there are several thousand, were made especially for this work and it has been the endeavor so to design and render these pictures that they will convey the desired information with a minimum of supplementary discussion.

The titles of the volumes are as follows: Vol. 1, Steam Boilers; Vol. 2, Steam Engine Principles and Practice; Vol. 3, Steam Power Plant Auxiliaries and Accessories; Vol. 4, Steam Turbine Principles and Practice; Vol. 5, Machinery Foundations and Erection; Vol. 6, Practical Heat—Part I; Vol. 7, Practical Heat—Part 2; Vol. 8, Electrical Machinery; Vol. 9, Practical Mathematics.

With the exception of Volumes 6 and 7 entitled Practical Heat, which has just been published, all of the volumes have been reviewed in these columns, and many of the readers may be familiar with them. With the publication of Practical Heat the series is completed, and the entire set may be had in a uniform style of binding for ready reference or study.

PULLING TOGETHER, by John T. Broderick with introduction by Charles P. Steinmetz; 168 pages, 5 by 7½ in., cloth; Schenectady, N. Y., 1923.

Not a power plant book, in fact, not even an engineering book, but a fine little treatise on human relations in industry. It is a book that every executive and every employe will find well worth reading.

It is a clear exposition and discussion of a plan which in one form or other is rapidly growing in favor and in many instances where it have been honestly tried, has led to increased co-operation. It tells in entertaining style the experiences of a modern executive with employe representation. In short, it is a valuable contribution on a most timely subject.

HICARB, a refractory put up in the form of plastic and paint, is described in a leaflet issued by Adams & Jewell of Rome, N. Y.

VICTORY double packed stop cock valves are described in a catalog issued by the Victory Mfg. Co., of Niles, Calif. This catalog gives information of interest to valve users in general and in particular with reference to their use in oil refineries.

COLUMBIAN STEEL TANK CO., of Kansas City, Mo., has issued a circular showing its new style of standard flask steam condenser for use in ice plants. This bulletin describes the welded construction of these condensers and shows how the design has been laid out to include extended head mountings, removable baffle plates and water condensing and cooling troughs on the sides.

LEAFLET No. 2064 issued by Allis-Chalmers Mfg. Co., of Milwaukee, describes the company's type S centrifugal pumps. This pump is built in capacities arranging from 25 gal. per min. upward and for a variety of users such as for condenser circulating water, condensate water, brine pumps, industrial plant water supply, etc. The leaflet gives some sectional views of the pump showing the design features.